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THE RELATIONS BETWEEN THE MIND AND THE NERVOUS SYSTEM.*

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IN order that one person may know what another person is talking about, there must be an agreement in regard to the meaning of the terms employed. Without this there can be no common ground on which those engaged in a discussion as speakers and listeners can stand. For it is obvious that if by a word one of the disputants means one thing and another by the same word means quite another thing, they will both talk of different things, and that hence their statements and arguments will be worse than useless, for they will not only have been of no avail in convincing an adversary or in instructing a pupil, but they will in all probability have been potent agencies in stirring up the bad blood that so often shows itself where, least of all, it ought to appear—in efforts to arrive at the truth.

It is especially necessary that there should be no misunderstanding in regard to one's terminology when we come to discuss those subjects in regard to which our knowledge is not full and precise, and which, consequently, have been studied from different stand-points by different inquirers, and by the light that their own minds have thrown upon them rather than by that of other minds. Suppose, for instance, that a doctor of music should go into the turpentine-regions of North Carolina to give a lecture on "pitch" to the dwellers in the pine-forests, and should talk of the elevation of the voice or of an instrument—is it not quite within the range of probability that some one of the audience would rise in indignation and tell the learned gentleman that he did not know what he was talking about, and that every man, woman, and

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child in the State knew that pitch was a "thick, black, sticky substance obtained by boiling down tar," and not only that, but he and the greater part of those present would feel as though their attendance had been obtained by false pretenses, and that the money they had paid for admission should be returned to them?

Or, if I should go out among the sturdy farmers of Northampton County and gather them together to hear a lecture on "ducks," and should confine my remarks to pets and darlings of the female part of the human species, is it not very certain that though the young agriculturists in search of wives would listen with eagerness to what I had to say (and it would be interesting, I think), the more sedate would feel as though I had played them a trick? Neither the young nor the old would have got what they came for, and yet there would be ample authority for the meaning given to the word.

And when I come before an educated assemblage such as this, composed to a great extent of persons of both sexes, who have been in the habit of thinking deeply on subjects of vast importance, and who have formed clear ideas of what meanings are to be given to the words they meet in their studies or use in their conversation, it is indispensable that if I wish to make myself understood and to speak with that force so essential in obtaining assent, I should do all in my power to avoid ambiguity of signification.

It would be very easy to bring before you many subjects in regard to which you have your own ideas, formed after much study and reflection, and to which, therefore, you would have a right to cling, and I should be obliged to start out by attempting to define accurately the terms to be employed. I doubt, however, if it would be possible to select one in which such a course would be more necessary than in that of which I am to speak to-day. The word "mind" is a little one, but it means a great deal, and if we strive for accuracy, as of course we should do, it means a great many different things. In fact, it is probable that, were I to send a canvasser among you, I should receive a hundred different explanations of the term, and nowhere would the variations be more numerous or more transcendental than among the eminent gentlemen—president, professors, and trustees—who constitute the governing body of this university; for I think I have observed that, the higher we go in mental development, the more numerous and refined are the differences as to what the mind is. No two metaphysicians ever yet exactly agreed in regard to the signification to be attached to the word mind.

But, before explaining to you my understanding of the term, it is necessary, in order to avoid all ground for misconception, to tell you what I do *not* mean. I do not mean the soul, although it and the mind are by a large and influential class of philosophers regarded as constituting one essence—as being, in fact, identical. With it, however, I conceive that we have nothing to do, so far as science goes. Its very

existence is a matter of faith in which, probably, most of us believe, but which is altogether beyond the limits of proof, or even of investigation. There is nothing tangible about it. We should not know how to proceed to ascertain the existence of the soul. No one could go into a court of justice and demonstrate by the rules of evidence that he himself, or his neighbor, has, as an integral part of his organization, a never-dying principle responsible to God for the deeds done in the body. He could not say that life is the soul, for, if he did, he would have to accord souls to all living beings, vegetables as well as animals. And, if he were to declare that the mind and the soul are identical, he would be obliged to admit that the "beasts that perish," and even the vine that creeps up the side of his house and finds out where the supports are situated around which it sends out its tendrils, have souls which, if not as perfect as his own, are none the less real. No, his belief in the existence of his soul rests upon higher principles than those that govern earthly tribunals or scientific investigation. He believes through the faith that is in him, not through the impressions that have reached his central nervous organs through his eyes or ears or nostrils or tongue or fingers—the only mediums by which actual knowledge can be obtained.

But with the mind it is very different. Its existence, its powers, its aberrations, are proved in courts every day, and we are constantly demonstrating its reality in our physiological and pathological laboratories, and in our hospitals and in the practice of our physicians. In fact, it is being shown every instant, in the person of every man, woman, and child, and in every living being throughout the earth, that mind exists and is a power. We see it exhibited in all its varieties. We are all of us familiar with good and bad minds, and some of us see human beings with minds so degraded and undeveloped that they are lower, so far as regards intelligence, than dogs or canary-birds. They do not know enough to reach out their hands and take the food that is placed before them, whereas we have all seen canary-birds haul up with their beaks whenever they were hungry the little wagons of seed on the outside of their cages.

But, though the minds of these poor beings are many of them inferior to those of our domestic animals, it would be presumption in us to say that the soul of the veriest idiot that breathes is not as pure and as high in the scale of souls as that of a Plato or a Newton. If the mind and the soul are identical, all those predisposing causes inherent in the parents, and which are capable of causing imbecility and idiocy in the offspring, are also capable of damaging the immortal soul that we believe God has given to every human being. The little piece of bone of a fractured skull that, pressing upon the brain, stupefies the mind, at the same time damages the soul; the congestion or inflammation of the brain that converts a man of giant intellect into a maniac or a dement beyond the hope of cure, also irreparably ruins

the soul, which, we are told, never dies, and which, if it exists, is doubtless far removed from the influence of bodily diseases or injuries.

Therefore I beg you to understand that what I have to say relates solely to the mind. Your souls are, doubtless, cared for by those whose qualifications for instructing you in their management are greater than any that I can claim.

Now, what is mind? Those of you who have thought much upon the subject will not be surprised when I say that I do not know. There may be others, however, who, though too polite to say so, may think it a piece of impertinence for me to come here to speak of something of the nature of which I am obliged at the very beginning of my discourse to confess my ignorance. But, if they thought thus, they would be doing me great injustice, and it would be easy for me to retaliate by asking them what a piece of wood is. Could they tell? Does any one know? Does any one know what anything is? There are sixty-four elementary bodies of which the earth is composed, but does any one know what a single one of them is? Take one with which you may be presumed to be especially familiar—iron. What is it? You do not know. You can describe it to me. You can point out its properties. You can tell me where it comes from. Yes, and I can do the same with the mind. I can tell you where it comes from, describe its properties, point out its manifestations, and you will recognize mind as clearly as I should recognize the iron, the qualities of which you should portray; but, as to telling you what mind is, I can not do it any more than you can tell me what iron is.

Some of you are students of physics. If you were to present yourselves in the class-room and ask your distinguished professor of that branch of science to tell you what heat, light, electricity, magnetism are, he would be obliged to tell you that he does not know, just as I am forced to tell you that I do not know what mind is. But, though he is ignorant of their essential natures, think of the vast fields of knowledge he is able to open up to you by putting you in possession of what is known of these forces!

Go into the chemical laboratory of your own noble university—in honor of whose founder we are here to-day—and touch the two poles of a galvanic battery. What is it that thrills through your bodies, and perhaps even burns the skin of your fingers; or, even, if the current be strong enough, strikes you dead on the instant? Galvanism. What is galvanism? A force. Yes, and so is light a force, and heat, and gravitation. But, when I am told this, I am just as far from knowing what any one of the forces is as I was before. All that you could do, if I persisted in asking for a fuller explanation, would be to tell me something of the origin and properties of the force in question, and in this way I should obtain some idea of its characteristics, and should be in no danger of mistaking it for any other force. That is what your Professor of Physics does for you,

and, if you have only profited by the instruction you have received, you have a store of facts at your command that will enable you to recognize heat, light, electricity, gravitation, magnetism, whenever you see them manifested. When, therefore, you ask me what mind is, I answer that it is a force possessing peculiar properties, and developed by a substance constituting a part of the nervous organism of man and other animals, and known to anatomists and physiologists as gray nerve-tissue. This is similar in all essential respects, so far as its terms are concerned, to the definition that you would give me of any other force. Of course, it can be made more precise and extensive, but no enlargement would change its character.

The gray nerve-tissue exists in the form of aggregations of minute cells in various parts of the nervous system. In man, by far the largest collections are found in the brain, and especially on the outside of it, covering it as the rind covers an orange, and hence called the cortex, or the cortical substance. Besides this large mass, spread out to the thickness of the twelfth of an inch or more over the exterior of the brain, there are masses of gray nerve-tissue in other parts, varying in size from that of a walnut to that of a small pea. In this diagram the situations of the masses of gray tissue existing in the brain are shown. You will observe a very beautiful arrangement for increasing the extent of the cortical substance without at the same time increasing the size of the brain, and thus making it heavier than it would be comfortable to carry. The surface is convoluted, and the gray matter, following the convolutions, is hence doubled over and over again on itself. If the cortex were spread out smoothly, like the skin on an apple, it would cover a body more than four times the size of the average human brain. We should, then, in order to get as much mind-producing substance as we have now, require heads four times the volume of those that we now carry on our shoulders. Gray nerve-tissue is found also in the spinal cord, and some animals, as the frog and the alligator, have more of it in this organ than they have in the brain. It also exists in connection with what is called the sympathetic nerve, in the form of masses called ganglia, and generally placed in intimate relation with the several vital organs of the body—as the heart, stomach, lungs, liver, etc.

Besides the gray nerve-tissue, there is another kind of nerve-substance called the white, and which, instead of consisting of granular forms or cells, is made up of tubes or fibers. The white nerve-substance has nothing to do with the evolution of nerve-force or mind. Its office is to transmit the nerve-force from the places where it is formed to other parts of the body. The great mass of the brain and of the spinal cord, and the whole of the nerves that ramify through the body, consist of white nerve-tissue. You will understand, therefore, that this substance is analogous to the wires of the telegraph, while the gray substance corresponds to the batteries.

And just as a particular arrangement, for instance, of zinc and carbon and sulphuric acid, leads to the evolution of galvanism, so a particular arrangement of nerve-cells leads to the evolution of the force that we call mind. We can not explain why or how the galvanism comes from the zinc, carbon, and sulphuric acid; neither can we tell why or how mind comes from the nerve-cells. Both are ultimate facts beyond which we can not go, and may never be enabled to go.

Now, as by their properties we recognize any of the other forces of Nature that I have mentioned, so by its properties we recognize mind. An object is perceived, and it is the mind that perceives it; an idea is formed, and it is the mind that forms it; an emotion is felt, and it is the mind that feels it; an act is willed, and it is the mind that wills it. Hence, there are these four groups of mental faculties, to one of which every possible manifestation of mind belongs—perception, intellect, emotion, and will.

The many interesting points concerned with these categories of mental faculties do not come within the scope of the present remarks, the chief object of which is to discuss the subject of the relations existing between the mind and the nervous system.

In the very earliest times of which we have any record, and even at the present day among barbarous nations, the idea existed that the brain was not the only organ concerned in the production of mind. Thus, the emotions were, many of them, supposed to have their seat in the heart, the liver, the spleen, the bowels. Love, for instance, was conceived by the heart, as were also several other tender or compassionate feelings. The liver was supposed to be intimately connected with the depressing emotions, the spleen with spite or revenge, and the bowels with pity. So strongly was this idea implanted, and so universally did it prevail, that it has influenced the forms of speech among all nations that are not so low in the scale as not to have emotions. Thus we say that a person has "a good heart," the lover tells his lady-love that he "loves her with all his heart," and the sinner when he turns away from his wickedness is said to have undergone a "change of heart." The influence ascribed to the liver is shown by our expressions "melancholic," "choleric," and by one that I heard used a short time since by a man who was complaining of an insult that had been put upon him, and who said that it made "his bile flow." Then we say of a disagreeable or quarrelsome person that he is "splenetic," or that he "vents his spleen," and we speak of a pitiless person by asserting that he has "no bowels of compassion."

How could the notions that gave birth to such expressions arise in the human mind? Doubtless, the origin was due to the fact that, under the influence of certain emotions, there are disturbances in the organs with which they are associated. Thus, the passion of love produces a sensation of fullness in the region of the heart, and the action of the organ is quickened. In mental depression, or as a consequence

of fits of anger, the liver is so deranged that the bile ceases to be produced, and pain is felt in that part of the body in which the liver is situated; and, when the emotion of pity is strongly experienced, a sensation of weakness, or, as it is sometimes called, a sinking feeling, is felt at the pit of the stomach.

It has been customary with modern writers—and I have until quite recently been of the like opinion—to regard these disturbances as being the effects of emotions that originated in the brain, and not as indicating that the organs in which they are felt have anything to do with the evolution of love or anger or fear or compassion, or any other passion or feeling. The idea has become so widely spread among educated persons that the brain is the only organ of the body that has any direct relation as a generator with the mind, that it seems like a tremendous blow at the system of existing facts to attempt to take from it any of its power. But it is only recently that physiologists and pathologists are beginning to make a thorough investigation into that great division of the nervous system consisting of the sympathetic nerves and their ganglia. If you will look at this diagram, you will obtain some idea of the situation and connections of these nerves. As you see, they are situated on each side of the spine, and are in direct connection with the brain, and their ramifications extend to every one of the vital organs situated in the chest, the abdomen, and the pelvis. These nerves differ from the other nerves—those that convey impulses to and from the brain—in the remarkable fact that they have at various parts of their course little swellings or enlargements called ganglia, and which consist of gray matter. Now, gray nerve-tissue, wherever it exists, is a generator of nerve-force, or mind, and it is not unreasonable to suppose, therefore, that these masses of the tissue in question, that are placed around the heart, the liver, the spine, and other organs, and in vast number in their substance, have some influence in causing the production of those emotions that make themselves felt in the parts of the body with which former universal beliefs and our present forms of speech have associated them. We find, too, as an additional fact in support of this view, that in certain mental affections, characterized by great emotional disturbances, these ganglia are in various parts of the body the seats of disease.

Therefore, there is some reason for the opinion that not to the brain alone do we owe the evolution of mind, but that the sympathetic system of nerves is also concerned in its production.

But there is another part of the nervous system not generally regarded as a mind-producing organ, but which I am very sure is directly concerned in the evolution of the force which so pre-eminently by its presence distinguishes organic from inorganic bodies, and that is the spinal cord.

The spinal cord is contained in the vertebral column, or, as it is popularly called, the backbone. It extends from the brain to near the

end of the trunk, and is at its thickest portion about the diameter of the end of the little finger. It contains throughout its whole length gray nerve-tissue arranged somewhat in the form of the letter H. The diagram to which I direct your attention shows the arrangement on a greatly magnified scale. More than nine years ago, in an address delivered before the New York Neurological Society, and entitled "The Brain not the Sole Organ of the Mind," I called attention to the fact that certain mental faculties are seated in the spinal cord. It will probably not be out of place if I adduce here some of the facts and arguments upon which I based that opinion, and which convince me of its correctness.

As we have just seen, all the manifestations of which the mind is capable in its fullest development are embraced in four groups—perception, the intellect, the emotions, and the will. Either one of these may be exercised independently of the others. Thus, an individual may have a perception without any intellectual, emotional, or volitional manifestation, and so the intellect, the emotions, or the will may be brought into action without the necessary participation of each other. It is, however, clearly established that all mental processes of any kind have their origin in perception, and that an individual born without the ability to perceive, either from defects in the external organs of the senses, or of the central ganglia by which impressions on these organs are converted into perceptions, would be devoid of intellect, emotion, and will—would be, in fact, lower in mental development than the most degraded types of animated beings. He would not, in fact, be able to conceive of so simple an idea as that one and one make two. How could he, unless he could see two objects, or hear two sounds, or smell two odors, or taste two flavors, or feel two tactile impressions? There would be no means by which he could differentiate one from two, for no knowledge on the subject could reach his brain. Though he might have the intellectual potentiality of Socrates, he would be an actual imbecile, without the slightest mental scintillation. The brain and other nerve-centers can only act from impressions received from without.

Perception is, therefore, the primary manifestation of mind, and is that part the office of which is to place the individual in relation with external objects. Thus an image is formed upon the retina, the optic nerve transmits the excitation to its ganglion, this at once functionates, the force called perception is evolved, and the image is perceived. If the retina be sufficiently diseased, the image is not formed; if the optic nerve is in an abnormal condition, the excitation is not transmitted; if the ganglion is disordered, the perceptive force is not evolved. Therefore, in order that a true perception may be experienced, an organ of sense, a nerve, and a mass of gray nerve-tissue are necessary, and no other organs are required.

It is rarely the case that an individual perceives an impression

made upon any one of the organs of the senses without a higher mental operation being performed. This is especially the case when the perception is of such a character as to be irritative. Thus, if an exceedingly bright light be allowed to impinge upon the retina, the brows are corrugated, and, if it be still more intense, the eyelids are closed so as to shut it out altogether; if a very loud noise strikes upon the tympanum, the head is turned so as to prevent the undulations of the atmosphere reaching the ear in full force; if the skin be irritated, the part is, if possible, drawn away, and, if the irritation be so great as to excite pain, the whole body is thrown into contortions and efforts are made to escape. Some of these movements appear to be involuntary, and even to be performed in direct opposition to the will, and then they are said to be reflex—that is, that they are the result of the conversion of a sensation into a motor impulse without the accompanying action of any ganglion, the action of which is the evolution of volitional force.

Now, it is very true that some of the actions in question are apparently altogether involuntary, and are thus true reflex movements, and it is no difficult matter to separate them from those other which are clearly volitional, determinate, and performed with a definite purpose in view. If, for instance, an irritative substance be applied to the interior of the nostril, the action which we call sneezing is produced. This consists of a spasmodic contraction of certain muscles by which the air in the lungs is forcibly expelled through the nostrils. It is automatic and preservative in character, the object being to get rid of the offending substance. It is always performed in the same way, the muscles brought into action are always the same, and it is spasmodic, sudden, and without deliberation or judgment, so far as we can determine from our own consciousness. Again, if the soles of the feet are tickled, they are drawn away, although it is possible for the impulse to remove them to be restrained by the exercise of the will, and, indeed, some individuals can prevent sneezing by strong volitional power evolved from the higher ganglia of the brain. But let us suppose the case of a man with a disease of the upper part of the spinal cord of such a character as to prevent its conveying volitional impulses from the brain to the muscles of the lower limbs; now let the soles of the feet be tickled, and we shall find that they are drawn away, and generally with very much more force than when the brain is allowed to act. Such a movement is probably one of true reflex character; it is spasmodic and indeterminate, being more extensive than is necessary. But let us go still further in our suppositions, and imagine that in such a case the mere drawing away of the foot was not sufficient to avoid the irritation, and that the individual deliberately lifted up the other foot in the attempt to remove the offending object, and that this action not proving adequate, he made two or three leaps in order to escape. What would we call these movements? Would they not be

evidence of perception and will? Would they not be movements performed with a definite purpose—the very best possible under the circumstances—to escape from the irritation, even though the brain were unconscious of them? It must be remembered that consciousness is not the necessary accompaniment of volition, as we shall presently see from examples I shall adduce; and this being the case, I can not avoid the conclusion that actions performed under the circumstances I have stated would be based upon perception and done through the power of volition.

Warm-blooded animals are for many reasons not suitable subjects for experiments such as are required in the study of the phenomena under consideration, but in some of the lower animals, as the frog, for instance, we find those conditions present which fit them for such investigations. Thus, if the entire brain be removed from a frog, the animal will continue to perform those functions which are immediately connected with the maintenance of life. The heart beats, the stomach digests, and the glands of the body continue to elaborate the several secretions proper to them. These actions are immediately due to the sympathetic system, though they soon cease if the spinal cord be materially injured. But, in addition, still more striking movements are effected—movements which are well calculated to excite astonishment in those who see them for the first time, and who have embraced the idea that all intelligence resides in the brain. For instance, if in such a frog the webs between the toes be pinched, the limb is immediately withdrawn; if the shoulder be scratched with a needle, the hind-foot of the same side is raised to remove the instrument; if the animal is held up by one leg, it struggles; if placed on its back—a position to which frogs have a great antipathy—it immediately turns over on its belly; if one foot be held firmly with a pair of forceps, the frog endeavors to draw it away; if unsuccessful, it places the other foot against the instrument and pushes firmly in the effort to remove it; still not succeeding, it writhes the body from side to side, and makes a movement forward.

All these and even more complicated motions are performed by the decapitated alligator, and in fact may be witnessed to some extent in all animals. I have repeatedly seen the headless body of the rattlesnake coil itself into a threatening attitude, and, when irritated, strike its bleeding trunk against the offending body. Upon one occasion, a teamster on the Western plains had decapitated one of these reptiles with his whip, and, while bending down to examine it more carefully, was struck by it full in the forehead; so powerful was the shock to his nervous system that he fainted and remained insensible for several minutes. According to Maine de Biran, Perrault reports that a viper whose head had been cut off moved determinedly toward its hole in the wall. I have performed a great many experiments and made numerous observations relative to the matter, and have for a number

of years taught, in my course of lectures on diseases of the mind and nervous system, the doctrine now set forth that, wherever there is gray nerve-tissue in action, there is mind. Into the detail of these experiments it is scarcely proper on this occasion to enter; suffice it to say that they all go to establish the fact that the spinal cord, after the complete removal of the brain, has the power of perception and volition, and that the actions performed are to all intents and purposes as perfect of their kind as they would be were the brain in its place.

As I have said, it is difficult to perform experiments of the kind in question on warm-blooded animals, for the hæmorrhage that results in consequence of the necessary cutting operation soon leads to the loss of life; but, for all that, we are not without information on the subject, derived from investigations of some of the higher animals. You have, most of you, seen a decapitated chicken staggering and fluttering about the barn-yard. Whence comes the force by which its movements are made, unless from other organs than the brain? This is a rough experiment that is performed every day, but in the laboratory we do it in a more careful way, and the results are still more striking.

If the brain be entirely removed from a pigeon, the bird turns its head in accordance with the motion given to a lighted candle held before its eyes; it smooths its feathers with its bill when they are ruffled; it places its head under its wing when it sleeps; it opens its eyes when a loud noise is made close to its head. Onimus removed the brain from young ducks hatched and brought up by a chicken. These ducks had never been in the water, yet when placed in a basin they immediately began to swim. Their motions in swimming were as regular as in other ducks which had lived in the water. This series of experiments shows that even the inborn instinct of animals is not solely resident in the brain.

Now, when we come to man, and observe the experiments which are constantly being made for us, both in health and disease, we can not avoid placing the spinal cord much higher as a nerve-center than it is usually placed by physiologists.

In human anencephalic monsters, or those born without a brain, we have interesting examples of the fact that the spinal cord is possessed of perception and volitional power. Syme describes one of these beings which lived for six months. Though very feeble, it had the faculty of sucking, and the several functions of the body appeared to be well performed. Its eyes clearly perceived the light, and during the night it cried if the candle was allowed to go out. After death the cranium was opened, and there was found to be an entire absence of the cerebrum, the place of which was occupied by a quantity of serous fluid contained in the arachnoid. The cerebellum and pons Varolii were present. Panizza, of Pavia, reports the case of a male

infant which lived eighteen hours. Respiration was established, but the child did not cry. Nevertheless, it was not insensible. Light impressed the eyes, for the pupils acted. A bitter juice put into the mouth was immediately rejected. Loud noises caused movements of the body. On *post-mortem* examination, there was found no vestige of either cerebrum or cerebellum, but the medulla oblongata and pons Varolii existed. There were no olfactory nerves; the optic nerves were atrophied, and the third and fourth pairs were wanting; all the other cranial nerves were present.

Ollivier d'Angers describes a monster of the female sex which lived twenty hours. It cried, and could suck and swallow. There was no brain, but the spinal cord and medulla oblongata were well developed.

Saviard relates the particulars of a case in which there were no cerebrum, cerebellum, or any other intracranial ganglion. The spinal cord began as a little red tumor on a level with the foramen magnum. Yet this being opened and shut its eyes, cried, sucked, and even ate broth. It lived four days.

Mr. Lawrence has published the details of a very interesting case in which there was no brain. But the excito-motory functions were well performed. The child moved briskly and gave evidence of feeling pain. Its breathing and temperature were natural, and it took food. Movements such as these do not afford evidence of a very high degree of intellect, but they are precisely such as are performed by all new-born infants possessed of brains. If they are not indicative of the existence of mind, we must deny this force to all human beings on their entrance into the world.

But we are not obliged to rest on the phenomena afforded by anencephalic monsters for all the evidence that the spinal cord of man is a center of perception and volition. We have only to observe the manifestations of its action which are of daily occurrence in our own persons. And in bringing them to your notice I shall quote from a little work on "Sleep and its Derangements," which I wrote a few years ago:

"If an individual engaged in reading a book allows his mind to be diverted to some other subject than that of which he is reading, he continues to see the words, which, however, make no impression on his brain, and he turns over the leaf whenever he reaches the bottom of the page, with as much regularity as though he comprehended every word he had read. He suddenly, perhaps, brings back his mind to the subject of his book, and then he finds that he has perused several pages without having received the slightest idea of their contents.

"Again, when, for instance, we are walking in the street and thinking of some engrossing circumstance, we turn the right corner and find ourselves where we intended to go, without being able to recall any of the events connected with the act of getting there."

In such instances as these—and many others might be adduced—the brain has been so occupied with a train of thought that it has taken no cognizance or superintendence of the actions of the body. The spinal cord has received the several sensorial impressions and has furnished the nervous force necessary to the performance of the various physical acts concerned in turning over the leaves, avoiding obstacles, taking the right route, and stopping in front of the right door.

All cases of what are called "absence of mind" belong to the same category. Here the brain is completely preoccupied with a subject of absorbing interest, and does not take cognizance of the events which are taking place around. An individual, for instance, is engaged in solving an abstruse mathematical problem. The whole power of the brain is taken up in this labor, and is not diverted by circumstances of minor importance. Whatever actions these circumstances may require are performed through the force originating in the spinal cord.

The phenomena of reverie are similar in some respects to those of somnambulism, to which attention will presently be directed. In this condition the mind pursues a train of reasoning often of the most fanciful character, but yet so abstract and intense that, though actions may be performed by the body, they have no relation with the current of thought, but are essentially automatic, and made in obedience to sensorial impressions which are not perceived by the brain. Thus, a person in a state of reverie will answer questions, obey commands involving a good deal of muscular action, and perform other complex acts, without disturbing the connection of his ideas. When the state of mental occupation has disappeared, there is no recollection of the acts which may have been performed. Memory resides in the brain, and can only take cognizance of those mental acts which spring from the brain, or of impressions which are made directly on the encephalon.

In the case of a person performing on the piano and at the same time carrying on a conversation, we have a most striking instance of the diverse though harmonious action of the brain and spinal cord. Here the mind is engaged with ideas, and the spinal cord directs the manipulations necessary to the proper rendering of the musical composition. A person who is not proficient in the use of this instrument can not at the same time play and converse with ease, because the spinal cord has not yet acquired a sufficient degree of automatism. Darwin gives a very striking example of the independent action of the brain and spinal cord. A young lady was playing on the piano a very difficult musical composition, which she performed with great skill and care, though she was observed to be agitated and preoccupied. When she had finished, she burst into tears. She had been intently watching the death-struggles of a favorite bird. Though the brain was thus absorbed, the spinal cord had not been diverted from the office of carrying on the muscular and automatic actions required by her musical performance.

In somnambulism the brain is asleep, and this quiescent state of the organ is often accompanied, in nervous and excitable persons, by an exalted condition of the spinal cord, and then we have the highest order of somnambulic manifestations, such as walking and the performance of complex and apparently systematic movements. If the sleep of the brain be somewhat less profound, and the spinal cord less excitable, the somnambulic manifestations do not extend beyond sleep-talking; a still less degree of cerebral inaction and of spinal irritability produces simply a restless sleep and a little muttering; and when the sleep is perfectly natural, and the nervous system of the individual well balanced, the movements do not extend beyond changing the position of the head and limbs and turning over in bed.

The phenomena of catalepsy, trance, and ecstasy are also indicative of an independent action of the spinal cord, inasmuch as the power of the brain is not exercised over the body, but is either quiescent or engrossed with subjects which have made a strong impression upon it. Some of the manifestations of mind shown under such conditions are exceedingly interesting, and are altogether outside of the domain of cerebral consciousness.

But notwithstanding the fact that the sympathetic system and the spinal cord share with the brain the office of producing mind, there is no question that this last-named organ, immeasurably in man at least, transcends them in power.

The brain is by far the largest mass of nerve-substance contained in the body of any animal possessing a brain; indeed, it far exceeds in bulk and weight all the rest of the nervous system together. The researches of European observers give 49½ ounces as the weight of the average brain of the white inhabitants of Europe—the maximum, that of Cuvier, being 64½ ounces, and the minimum, consistent with a fair degree of intelligence, 34 ounces. Webster's brain (allowance being made for disease which existed) weighed 63¾ ounces, Dr. Abercrombie's 63 ounces, and Spurzheim's 55 1/16 ounces. The average of twenty-four American brains, accurately weighed by Dr. Ira Russell, was 52·06 ounces—the maximum 64 and the minimum 44·25 ounces. The same observer found the average full negro brain, as determined from 147 specimens, to be but 46·96 ounces.

The capacity of Daniel Webster's cranium was the largest on record, being 122 cubic inches. That of the Teutonic family, including English, Germans, and Americans, is 92 cubic inches. In the native African negro it is 83 cubic inches, and in the Australian and Hottentot but 75. The brain of the idiot seldom weighs over 23 ounces, and it is often much less than this. In one instance coming under my own observation, the weight of the entire brain was but 14½ ounces. Mr. Gore has related in the "Anthropological Review" the particulars of a case of microcephaly in which the brain weighed but 10 ounces and 5 grains. The subject, a female, though forty-two years of age, had

an intellect which is described as infantine. She could say a few words, such as "good," "child," "morning," with tolerable distinctness, but without connection or clear meaning, and was quite incapable of anything like conversation. Her habits were decent and cleanly, but she could not feed herself—at least with any degree of method or precision. She was fond of carrying and nursing a doll. In a case described in a subsequent number of the same journal, by Professor Marshall, the weight of the entire brain was but 8½ ounces. The subject was a boy twelve years of age. Nothing is said relative to the intelligence manifested.

Absolutely, the normal human brain is larger than that of any other animal, except that of the elephant and the whale. *Relatively to the weight of the body*, it very greatly exceeds the proportion existing in either. Leuret found the mean proportional weight of the brain to the rest of the body to be in fishes as 1 to 5,668. The range in these animals is, however, very great. In the bass, I found it, as the result of eleven observations, to be as 1 to 523; in the eel, twenty-two observations, as 1 to 1,429; and in the gar-fish, nine observations, as 1 to 8,915.

In reptiles of different orders Leuret determined the average to be as 1 to 1,321. I found the proportion in frogs to be as 1 to 520; in lizards, as 1 to 180; and, in the rattlesnake, as 1 to 1,825. The brain of an alligator, over six feet in length, which I examined, weighed but a little over half an ounce.

Next in order come the birds, and here we find a very decided increase in the proportion. From many determinations made by Haller, Cuvier, Carus, and himself, Leuret gives the average as 1 to 212. In the tomtit he found it as 1 to 12; in the canary-bird, as 1 to 14; in the pigeon, as 1 to 91; in the duck, as 1 to 241; in the chicken, as 1 to 377; and, in the goose, as 1 to 3,600. These are very great differences, and, as Leuret remarks, have no constant relation to the intelligence. It is worthy of notice that the brain is proportionally smaller in those birds which are domesticated, and which, consequently, do not have to make so severe a struggle for existence, than in the wild birds; and their brains, therefore, are more encumbered by fat. From determinations that I made, it was ascertained that the brain of the canary-bird reared in the United States was in weight compared to that of the body as 1 to 10·5, and in the Arctic sparrow as 1 to 11. No observations on record show proportionally larger brains than these.

Among mammals we find a still greater increase in the weight of the brain as compared with that of the body. Leuret found it to range in the monkeys from as 1 to 22, 24, and 25; in the dolphin it was as 1 to 36; in the cat, as 1 to 94; in the rat, as 1 to 130; in the fox, as 1 to 205; in the dog, as 1 to 305; in the sheep, as 1 to 351; in the horse, as 1 to 700; and, in the ox, as 1 to 750. The mean for

the class of mammals, exclusive of man, was as 1 to 186. My own observations accord very closely with those of Leuret. I found that in the prairie-wolf the proportion between the brain and the body was as 1 to 220; in the wild cat, as 1 to 158; and in the rat, as 1 to 132.

If these figures teach anything at all, it is that there is no definite relation existing between the intelligence of animals and the absolute or relative size of the brain. It is true that, taking the data collected by Leuret as the basis, there is a well-defined relation between the mental development and the brain, as regards the several classes of vertebrate animals; for in fishes, the lowest, the brain is but one 5,668th part of the body; in reptiles, the next highest, it is one 1,321st part; in birds, next in the ascending scale, it is one 212th part; and in mammals, the highest of all, one 186th part. There is, therefore, beginning with the lowest class, a regular ascent in the volume of the brain till it reaches the maximum in mammals.

But, when we look at the relation as it exists between the different orders and genera of any one class, we can not say that there is any such variation in the degree of mental development as we should expect to find if the brain were the only source of the intelligence, and some members of the very lowest class have relatively larger brains than certain animals of the very highest. Thus, the brain of the bass is to the body as 1 to 523, while in the horse it is but as 1 to 700, and in the ox as 1 to 750. If the relative size of the brain is to be taken as an indication of the degree of intelligence, we must regard the bass as a more intellectual animal than either the horse or the ox. The lizard has a brain which bears the high proportion to the body of 1 to 180. This is greater than that existing in the fox, the dog, the sheep, and several other mammals. The canary-bird and the Arctic sparrow have brains proportionately larger than those of any other known animals, including man, and yet no one will contend that these animals stand at the top of the scale of mental development. Man, who certainly stands at the head of the class of mammals, and of all other animals, so far as mind is concerned, rarely has a brain more than one fiftieth the weight of the body, a proportion which is much greater in several other mammals, and is, as we have seen, exceeded by many of the smaller birds.

Even in absolute weight, independent of any relation to the rest of the body, the brain of man is not the largest, being exceeded by that of the elephant and the whale. But, when we inquire into the matter of the absolute and relative quantity of gray nerve-tissue, we find that in this respect man stands pre-eminent; and it is to this fact that he owes the great mental development which places him so far above all other living beings, for it is the gray tissue which originates mind—the white, as is well known, serving only for the transmission of impressions and impulses. Unless regard is paid to this point, we should certainly fall into serious error in determining the relation

existing between the mind and the nervous system; but, having it in view, the connection is at once clear and well defined, there being no exception to the law that the mental development is in direct proportion to the amount of gray matter entering into the composition of the nervous system of any animal of any kind whatever.

A point which attracts a good deal of attention at the present day is that which relates to the differences in the brain and mind as exhibited in the sexes of the human species. A few words on this division of the subject may not, therefore, be out of place.

The skull of the male is of greater capacity than that of the female, and it is a singular fact that the difference in favor of the male increases with civilization. Thus, in savage nations, as the Australians and the negroes of Africa, the skulls of men and women are much more alike in size than they are in Europeans. It would appear from this fact either that women, from some cause or other, have not availed themselves of the advantages of civilization, as factors in brain development, to the same extent that man has; or that, among savages, there is not that dissimilarity in mental work that is found in civilized nations; and that, hence, there is not the same necessity for a difference in brain-development.

For it naturally follows that, in the normal skull, there is a correspondence between its size and that of the organ contained within it. Many observations have shown that the average male brain weighs a little over forty-nine ounces, while the average female brain is a little over forty-four ounces, or about five ounces less. The proportion existing between the two is, therefore, as 100 to 90.

This apparently makes a good showing for man, but, when we look at the matter in another and possibly a more correct light, the advantage is rather the other way, for, relatively to the weight of the body in the two sexes, the difference, what there is, is in favor of woman. The body of the female is shorter, and weighs less, than that of the male. Thus, in man the weight of the brain to that of the body has been found to be an average of 1 to 36·50, while in woman it was as 1 to 36·46. I have said that *possibly* this may be a more correct way of determining the size of the brain than by absolute measurements, without regard to the size of the body. The doubt arises from the fact that we do not know that very thin persons, in whom, of course, other things being equal, the brain would be relatively larger, are more remarkable for mental vigor than very stout ones, in whom the relative size of the brain would be less. Such being the case, it is difficult to believe that the proportionate size of the brain to that of the body has any important influence as a factor in the production of mind. It is the *absolute*, rather than the relative, amount of gray matter that is to be considered in determining the brain-power.

It must, however, be borne in mind that the quantity of gray matter can not be positively affirmed from a determination of the size

of the brain, though in general it can. A person, for instance, may have a large head and a large brain, and the layer of cortical substance be very thin; and another person, with a smaller brain, may have the cortex so thick as to more than compensate for its small superficies. Still, these are exceptional cases. As a rule, the larger the brain, the greater the mental power of the individual.

Another difference between the brain of man and that of woman is found in the conformation of the organ. In man the frontal region is more developed than it is in woman. There is a certain fissure, called the fissure of Rolando, which I point out here on this model. Now, if we take the entire length of the brain as = 100, there will be found in woman 31·3 in front of the upper end of this fissure, while in man there will be 43·9.

Again, the specific gravity of the male brain, both of the white and the gray substance, is greater in man than it is in woman.

It is difficult from these facts to avoid the conclusion that the mind must also be different in the two sexes—not necessarily that one is superior to the other, but that they are different. In some respects that of man excels, in other respects that of woman predominates. It would be a bad state of affairs for mankind if the mind in the two primary divisions of the human race were the same. In barbarous nations, as we have seen, the difference in size is less than it is with civilized peoples, and as one consequence of this fact we find that there is not so great a difference in the mental development. The work of a woman with these is almost the same as that of a man. Her mode of life, her dress, are not essentially different, except in so far as they *must* be different on account of her sex. But with civilized nations there is variety in modes of thought and in other mental characteristics, in occupation, in manner, in dress, so that the differentiation between the sexes is far more distinctly marked than it is in the nations low in the scale of progress. Who can doubt that this is the direct result of difference, not only in the brain but in other parts of the nervous system? It appears to me, therefore, that while the education of a woman should be just as thorough as that of a man, it ought not to be the same. The two sexes move along paths that approach parallelism at some points of their course, but they can never travel exactly the same road till they have nervous systems presenting exactly the same anatomical configuration and structure.

Another point—and it is one of such practical importance that it would scarcely do for me to pass it over—and that is the influence of age in affecting the relations existing between the mind and the nervous system.

Most civilized communities have enacted laws against the employment of children in severe physical labor. This is well enough, for the muscles of young persons are tender and weak, and not therefore adapted to the work to which cupidity or ignorance would otherwise

subject them. But no such fostering care does the State take of the brains of the young. There are no laws to prevent the undeveloped nervous system being overtasked and brought to disease or even absolute destruction. Every physician sees cases of the kind, and wonders how parents of intelligence can be so blind to the welfare of their offspring as to force or even to allow their brains to be worked to a degree that in many cases results in idiocy or death. Only a few months ago I saw for the first time a boy of five years of age, with a large head, a prominent forehead, and all the other signs of mental precocity. He had read the first volume of Bryant's "History of the United States," and was preparing to tackle the other volumes! He read the magazines of the day with as much interest as did his father, and conversed with equal facility on the politics of the period. But a few weeks before I saw him he had begun to walk in his sleep, then chorea had made its appearance, and on the day before he was brought to me he had had a well-marked epileptic paroxysm. Already his mind is weakened—perhaps permanently so. Such cases are not isolated ones. They are continually occurring.

The period of early childhood—say up to seven or eight years of age—is that during which the brain and other parts of the nervous system are most actively developing, in order to fit them for the great work before them. It is safe to say that the only instruction given during this time should be that which consists in teaching children how to observe. The perceptive faculties alone should be made the subjects of systematic attempts at development. The child should be taught how to use its senses, and especially how to see, hear, and touch. In this manner knowledge would be acquired in the way that is preeminently the natural way, and ample food would be furnished for the child's reflective powers.

And now I must bring these remarks to a close, although there is a great deal yet that, were there time, and I were not afraid of wearying you, I should be glad to say. One point, however, must not be overlooked, and that is, the occasion that enables me to come before you at all. It is not likely that the world, and especially Pennsylvania, will ever forget the wise man who laid the foundations of this institution of learning. It is not yet venerable by age, but, when it counts as many centuries of existence as it now counts years, the name of Asa Packer will stand first among those that it will delight to honor. More than forty years ago, when I was a boy in Harrisburg, and he was a State Senator from Northampton County, I knew him well, and his personal appearance and manner are firmly fixed in my mind as he was then, a man of perhaps thirty-five to forty years of age. I recollect that upon one occasion I met him at the corner of Market and Third Streets, as he was on his way to the Capitol, and that he invited me to walk with him to the building. I was then a school-boy, and he questioned me very closely in regard to the profession I proposed

to adopt. I had then no very positive ideas on the subject. I had thought of the church, of law, and of medicine, and so I told him. We were then about half-way up the board-walk that extended from the corner of Third and Walnut Streets to the Capitol-grounds. He stopped, and, turning to me, said: "Ah, my young friend, the most difficult task you have before you is to make the right choice. A bad start at the beginning is almost certain to result in a bad race and a bad finish. Don't leave it to chance. Think it over, and then decide."

I thanked him.

"One thing more," he said. "If, after you have decided, you find that you have acted hastily and without the knowledge of yourself that was necessary, don't be afraid or ashamed to change. Don't stick to a profession for which you are unsuited merely for the sake of sticking. It is better, however, to be sure in the first place."

Perhaps even at that time he had it in his mind to found this university. The world knows that he made no mistake. He had determined what to do, and how to do it; his brain worked easily and it worked well; and what he apparently did in the way of accumulating wealth for his own advantage was in reality done for the advantage of his fellow-creatures, whom he loved as members of the universal brotherhood to which he belonged.

GERMAN TESTIMONY ON THE CLASSICS QUESTION.

By FREDERIK A. FERNALD.

THE German practical-schools (*Realschulen*) are a recent institution as compared with the classical-schools (*Gymnasien*), and have never yet obtained more than a scanty allowance from the public treasury, from which their ancient rivals have long received an abundant support. But, in spite of this and many other disadvantages, the practical-schools have gradually increased in efficiency until they now furnish a training which, in the opinion of a large party in Germany, prepares students to enter upon a university course. In compliance with the demand of this party, the Prussian Minister of Public Instruction, in December, 1870, ordered that graduates of practical-schools of the first class should be admitted to courses in modern languages, mathematics, and natural science, at the universities of Prussia, withholding from them, however, admission to the studies of mental philosophy, philology, history, political economy, law, theology, and medicine, and leaving closed the avenues to the majority of state appointments, which are immensely more important to university men in Germany than in the United States. After an experience of eight years the Philosophical faculty of the Friedrich Wilhelm

University in Berlin reported that the graduates of the practical-schools were poorer material than those sent up from the older schools, and assigned theoretical reasons for the deficiency. This report has been widely quoted in this country as deciding a question on which it had little, if any, bearing—namely, whether Latin and Greek are the best studies for early mental training. Great capital was likewise made of the fact that Professor Hofmann, who is a chemist, on assuming the rectorship of the University of Berlin, reiterated the conclusions of the faculty, and apparently acknowledged the pre-eminence claimed for the classics; but it is quite significant that the classical men failed to get any such public utterance from him during his visit to the United States last fall as they got from Lord Coleridge and Matthew Arnold. The numerous causes and considerations which led to the adverse report of the Berlin faculty have been ably set forth by Professor E. J. James, in an article on "The Classical Question in Germany," published in "The Popular Science Monthly" for January, 1884.

But the impression still persists that this decision of the principal state university in favor of the classical-schools and against the practical-schools, has something of the import of a German Government manifesto, and of a final answer to the question, upon which the culture and scholarship of that country are agreed. This, however, is a very great mistake. So far from quieting it, the celebrated Berlin report did not have sufficient influence in its own country to materially check the agitation of the classics question. The controversy over the traditional classical study, of which the practical-schools are a product, had raged long and hotly, taking a profound hold of the public mind, and the discussion goes on without abatement of interest or vigor, as may be inferred from the following introduction to a pamphlet* written nine months after the presentation of the report:

"The present condition of our secondary-school system must incite every thinking person to serious reflection. We see a school for the cultivated, aiming almost exclusively at acquaintance with classical antiquity, while an indescribable ignorance of the ancient civilization prevails among almost all classes; an eternal dispute in the daily press, and in most circles, as to whether Latin or Greek or both are indispensable in education; and a vast gulf between the two prevailing cultures, due to the difference between the ideals of the classical-school and of the practical-school. There is also a restless fluctuation in the prescriptions for the examination of one-year volunteers; a violent contest in regard to whether admission to the study of medicine shall be confined to classical-school graduates; and, finally, a decrease, perceptible to the superficial observer even, of intellectual workers, which means a general abatement of intellectual life so far

* "Betrachtungen über unser classisches Schulwesen," Leipsic, Verlag von Ambr. Abel, 1881.

as it is not comprised in the profession of the individual, and which is visible not only when men are observed as they come together in society, but also in their domestic lives. These things present an unpleasing aspect, and incite us to search for their cause and to devise means of correcting them. How much the school question is already occupying the attention of thinking men is shown by the multitude of pamphlets which yearly flood the book-market."

After a hasty glance at the history of the German classical-school, this writer presents his indictment of the study of Latin and Greek, and supports his view by a host of citations from German authorities, some of which we give in the present article. He says:

"The learning of Latin has no more cultivating influence than the learning of any modern cultivated language, while other considerations strongly urge the introduction of French and English into the course of study of the secondary schools in place of Latin. The acquaintance with Latin which the learned require could be obtained during the last three years, in voluntary classes, and in a different way from the one in vogue.

"It is, indeed, undeniable that acquaintance with the ancient civilization is an important force in modern civilization, but a view of the classic world of the Greeks and Romans may be had without acquiring the ancient languages.

"When the number of hours devoted to the ancient languages in nine school-years is impartially set beside the results which are obtained, this expenditure of time must be accounted unjustifiable.

"Knowledge of classical antiquity and its authors is in a steady decline among the learned, and for this sad state of affairs modern classical philology is to be held accountable."

The claim that the reading of ancient authors is the only adequate means of becoming acquainted with the ancient civilization is not supported by the results. As President Eliot says, "It is a very rare scholar who has not learned much more about the Jews, the Greeks, or the Romans, through English than through Hebrew, Greek, or Latin." The obviously proper procedure is for the student to learn the broad traits of a people and their civilization through his own language, and then to glean by means of the ancient language whatever has so far escaped him. The experience of our pamphleteer in respect to this is very instructive:

"It was a source of continual wonder to me in my school-days, that some of my fellows, who attended the common school (*Bürgerschule*), actually knew more about the times of Pericles and Augustus than we, the learned Latinists and Greekists. The reason was, that in the common school there taught the author of a well-known history, who knew how to combine intimately the study of history, of literature, and of manners and customs, so that the boys obtained a lively introduction to ancient times, while we had to give our attention to

the language of the classic writers in the Latin and Greek classes, and the history class, for which we had to learn by heart the dry paragraphs of an outline, was entirely disconnected from them."

On this point Paul Pfizer wrote in his "Correspondence of Two Germans" (1831): "In the construing of ancient writers, as it is carried on in the schools, the spirit of modern life is simply lost, without that of the past being gained. . . . Among us twelve years of youthful life is sacrificed to the study of a dead language which the student learns neither to speak nor to write, and very promptly forgets, while the opportunities of parading this unfruitful possession are becoming scarcer and scarcer."

The slight acquaintance with antiquity and the imperfect command of the classical languages gained by school-boys having been often pointed out, the study is now defended mainly on the ground that the most valuable mental exercise is obtained from wrestling with the grammars. It is interesting to note what value this use of the dead languages had in the estimation of Herder:

"As soon as learning Latin is made an end, and this in itself so pleasing and useful language is no longer employed as a means of learning history, of looking into the minds of great men, and of making one's own the whole field of an excellently developed language, then the Muses of Latium are allowed too much space in the schools. To be more particular, if the interpretation of an author affords nothing but words and mechanical style for the pupils to learn, if the method of the teacher has for its chief aim only the grammatical choice and arrangement of words, and if the whole school or educational system is controlled by a certain *Latin spirit*, which must produce a sad deficiency in other branches, then, however admirable and useful the Latin language may be, too much is sacrificed to it."

Again, Paul Pfizer: "The fact that from the 'school of the ancients' excellent men have come forth proves nothing as to the exclusive pre-eminence of Latin-learning, with its eternal translating, its verse-making, and its phrase-twisting. Not from the school of the ancients, but from the hand of Nature, have these men come forth, and the acquiring of Arabic or Persian would have done them about the same service."

It may be objected that most teachers of the classics do not report any such discouraging failures. Are they not likely to know best the condition of their own business? The pamphlet before me contains a passage which shows that declarations of teachers, among which the famous "Berlin report" should be counted, must be taken with several grains of salt, thus aptly re-enforcing the article by Professor James already referred to:

"The resolutions which are passed by bodies of teachers can not be regarded as representing the actual state of affairs. Against the complaints or remonstrances of the laity the teachers stand as one

man, and decide that there is nothing at all to complain of. That is the way they always do when fault is found with their neglect of health and bodily culture, and when, every couple of years, complaints are made of the overloading the pupils with work. Moreover, if they withhold and deny their opinions in deference to Government, how can any dependence be placed on their conclusions? At a recent meeting of practical-school teachers, one of them spoke against the extension of the study of Latin in the practical-school, and moved a resolution in reference to it. One of the wiseacres present promptly objected that this ought not to pass, for *he knew that the authorities laid great stress on Latin!* . . . Conventions of physicians have advanced as a chief reason why admission to the study of medicine should be refused to practical-school graduates, that by this means the social position of physicians would be injured."

To this may be added a few sentences from Herder:

"And then can a view, although it should be recognized as the true one, destroy prejudices deeply rooted since youth, which have become a second nature to the instructors? . . . Can it so seize upon pedantic souls that when it shows itself in full light it shall cause them to act in accordance with it? . . . Oppressed spirits! martyrs of a Latin education! O that you could all cry aloud!"

The reason why the two most widely known German writers can not be quoted with Herder, Pfizer, Richter, and the others, on this side of the question, is thus stated in the pamphlet before me:

"If it occurs to any one that testimony from Goethe and Schiller is almost entirely lacking, let him remember that neither of the poets had attended the higher *Normalschule* of his time. Schiller was a pupil of the *Karlsschule*, which had long ceased to occupy the narrow ground of the classical-schools of the time, and Goethe received a careful and varied private instruction, and hence did not suffer from the contemporary school education."

Leaving now the course of study of the classical-schools, the author proceeds to dispel a delusion which the utterances of numerous speakers and writers during the past year has shown to prevail even more in the United States than in Germany.

"Since we have made so many and, in the eyes of many persons, so spiteful attacks on the classical-school, it might be supposed that the modern practical-school is the El Dorado in which we see our pedagogic desires realized. It is, indeed, astonishing, we declare it thankfully, what a fresh and active life the practical-school, formerly treated in such a step-motherly way by the state, has developed in often victorious competition with the sluggish, though officially fondled and fostered, classical-school; how brightly and sturdily there have come up in it not only the natural sciences, but also, to the shame of the classical-schools it must be said, the study of the German language and literature, but we must remain true to our ideal of education and

not allow the heritage of the ancient humanistic culture to this inconsistent system. . . . Through many practical-schools—and this often less on account of the studies taught than of the superficially practical training of the teachers—there runs a certain strain of philosophical and ethical crudity. That many teachers possess only a scientific and partial culture is generally less their own fault than that of the irregularity which characterizes the examinations of these teachers by the authorities.

"It is a most ridiculous position which Latin occupies in the practical-school. It bears no relation to any of the other branches, and, since the pupils learn French quicker than Latin, it is senseless to say that they learn Latin in order to be able to learn the modern languages."

The author then sketches the course of study of the ideal secondary school, but fails to preserve the proper balance between the several studies, from having no adequate conception of an important one of them. He has something to say about natural science, but does not know why, how, or when it should be studied. Apparently no glimmer of psychology has ever entered his mind; at least, not a ray is reflected. Not sufficiently conscious of his defect to refrain from what he is incompetent to perform, he is yet so far aware of it as to make a confession in these words:

"Unfortunately we ourselves, thanks to our classical training, are too strange in this realm to be able to determine how far and in what way the sciences referred to are to be taught in school without either those parts of the natural sciences which constitute an element of general modern culture being omitted, or things being dragged in which would be better left for presentation by the university instructor. The answers to these questions must come from men who are familiar with the natural sciences without being prepossessed by them."

The advocates of a wider choice of studies in American education are of two classes: One class, admitting the claims of linguistic training to superiority, asks only the option of employing either ancient or modern languages, saving a little space, perhaps, for natural science. The other class holds, first of all, that the art of education must be based upon the science of psychology, and that the symmetrical development and highest efficiency of the mind can be secured only through a training which gives the due amount of exercise to each faculty. It has long been recognized as an absurdity to suppose that the muscular part of the human organism gets its best development from any one kind of hard work. The stone-cutter or machinist may have strong arms, with very defective legs. The coal-heaver will be strong in the back, but will have a stooping posture and a cramped chest; much rowing produces about the same development. Similarly with the brain. The most prolonged and severe exercise of the memory will not perceptibly improve the observing powers, and no amount of drill

in observation will secure a full development of the powers of abstract thought. This matter is very fully and clearly set forth in Mr. James Sully's new work, "Outlines of Psychology." "In the second place," continues Mr. Sully, "the whole scheme of training should conform to the natural order of development of the faculties. Those faculties which develop first must be exercised first. It is vain, for example, to try to cultivate the power of abstraction before the powers of observation (perception) and imagination have reached a certain degree of strength. This self-evident proposition is one of the best accepted principles in the modern theory of education, though there is reason to apprehend that it is still frequently violated in practice."

The course of study for boys until they are eighteen years old which conforms to these principles would be as follows: Since sensation is the first faculty to be born, the first lessons should consist in presenting to the child objects on which he can exercise this faculty. This is the method of the Kindergarten, and has sufficiently demonstrated its wisdom. Gradually the child should be led to make more and more minute and complete observations, and plants, animals, and minerals should be put within his reach for comparison and classification. Next he should be set to discovering the physical properties of matter and the laws of force, and after this the chemical properties of matter should be investigated to some extent. Human physiology and hygiene should also form a part of the course. These subjects should be so arranged that a part of the pupil's time throughout his school course would be devoted to the scientific method of studying things, which is a far different matter from committing to memory the pages of the ordinary text-book on science, or sitting passively like a pitcher under a spout while the teacher pours information into listless ears, perhaps showing experiments and specimens, and telling the pupils what to see. The benefits of scientific culture have been often and ably stated. One of the most important is that it prevents the disastrous credulity which prevails even among those accounted well educated according to the ancient standard. If the opponents of science had been familiar with the scientific method of getting at truth, as exemplified, for instance, by the classical experiments, of Sir Humphry Davy on the electrolysis of water, they would not have so eagerly published their understanding of the "Berlin report" without a single attempt to eliminate sources of error.

The study of language also should run through the whole school course. The process of learning to talk should be continued in the school, the pupil's discoveries about things furnishing the subject-matter on which to exercise his powers of expression. He should begin early to write a part of what he has to say, and may thus be introduced to Composition without knowing the dread which that big name commonly inspires in the minds of school-children. Elocution should receive some attention, and the derivation and composition of

English words should be studied to the extent that they aid in remembering distinctions in meanings. The pupil should obtain also some adequate knowledge of the history of English literature, and of its extent, its beauties, grandeur, and wisdom. At present students are admitted to the best American colleges, whose ignorance of their native language and its literature is positively shameful. The study of grammar should not begin until the boy is sixteen years old. At twelve or fourteen years old he may begin to learn to talk in another modern language, and may continue the study of this language to the end of his school course. These are enough subjects in language; the other modern languages and Latin and Greek should be left to the college course, as German, Spanish, Italian, and Hebrew commonly are. In direct opposition to this method of procedure is the practice of putting boys into the grammatical study of languages at ten or eleven years of age, and its pernicious effect is well stated by Herder:

"The first color which our mode of thinking takes on never fades; alas for us if it is a disagreeable or an actually disfiguring one! The friend of humanity must sigh when he sees how, in the schools which parade the name 'Latin school,' the first young desire is wearied, the first fresh strength is restrained, talent is buried in the dust, and genius is held back until, like a spring too long bent, it loses its power. Who would ever get into the notion that the system of *linguistic education* is suitable for youth, if he only set himself outside of our habit of thought?—but how difficult it is to set one's self outside of it!"

The opinions of our pamphleteer on the study of languages are well worth quoting:

"The chief place in the German school of the future should be held by a course of instruction in the German language and literature which aims at so training youth that at the end of their school-years they shall be adepts in speaking, reading, and writing their mother-tongue, and shall, besides being familiar with the copious vocabulary of the language, have become acquainted also with its literary monuments and imbued with the intellectual spirit of their nation. It is obvious that, in order to turn out such pupils, teachers are needed who know more than some Gothic and Middle High German, and it is also obvious that in order to obtain such teachers, those learned men should not act at the university who have lost the spirit in turning over the words, and who, moreover, pass off this spiritlessness for scholarliness.

"French and English also have large claims: first, because an acquaintance with these languages is absolutely necessary in many callings, and is always very useful to the educated; second, because the civilizations of the French and English peoples stand in the most intimate relations with ours; and, third, because he who has mastered these two languages no longer has the trammeled feeling that his path of life is confined to his native sod, but he can turn his steps to any part of

the civilized world to seek his fortune, if he does not find it at home. The instruction in these languages, which, being living languages, must be treated accordingly, can properly aim only to teach the pupils to speak, read, and write them. Without neglecting the practical considerations, the pupils may be exercised in logical thinking by means of the grammars of these languages, and in the upper classes their lingual facility may be increased by free translation into German. Surveys of the literatures of the two peoples, with specimens, will incite talented pupils to devote themselves to the thorough study of these literatures at the university."

Americans who had given adequate attention to modern languages would be able to read such valuable documents as the "Berlin report" and Dr. Hofmann's address, without understanding the word "*wissenschaftlich*" in a much-quoted passage to mean "scientific," relating to natural science, when it really means relating to knowledge, scholarly. *Die schoenen Wissenschaften* are not a class of natural sciences, but polite literature. The complaint that modern languages are too easy to afford valuable mental discipline should not be urged by writers who make such slips in German.

The postponing of Latin grammar until the pupil's mind approaches maturity is thus emphatically indorsed by Jean Paul Richter: "It pleased me to hear you state that you would have French come before Latin, speaking before grammatical rules (i. e., the go-cart before the theories of muscular action), and have the ancient languages taken up later, because they are taken in more by the reason than by the memory. Latin is so hard partly because it is brought on so early; in his fifteenth year, a boy accomplishes in it with one finger what he would take the whole hand for earlier." In full agreement with Richter's view is the following passage from Paul Pfizer: "Or is it maintained by the majority of our philological and humanistic instructors that in them antiquity is alive? And what is not the case among the teachers, will that be among the pupils? It is maintained that there is nothing more alive than the writings of the ancients. But in order to enter into this life, to become at home in a strange world, and to awaken the past again in one's self, a fullness of creative power is required, and a maturity of spirit and insight, such as are never to be found in youth."

I have known young men who did not decide to go to college until they were eighteen or twenty years old, and then accomplished in two years or less the preparation in Greek and Latin which drags over four to six years in the ordinary preparatory school. Students at Harvard learn enough German during the freshman year to be able to translate three pages at a lesson from such a book as Schiller's "Thirty Years' War." When students elect Hebrew or Sanskrit they make proportionate progress, hence it must be admitted that the knowledge of Greek and Latin required by the man of general culture, not the spe-

cialist who expects to earn his bread and butter by teaching the classics, may be gained after the student has entered college in half the time commonly devoted to its acquisition in the schools.

The ideal school course would allow a share of time to mathematics continuously, and this subject may be passed over with a few words, not because it is unimportant, but because, unlike Greek and Latin, it "needs no bush." It may be mentioned that practice in deductive reasoning, for which mathematics is chiefly recommended, is obtained especially from "mental" arithmetic and geometry, while "written" arithmetic and algebra are less important for this purpose. Some time must be devoted to learning those facts of physical and political geography which the educated man is expected to know. Every English-speaking boy should become familiar with the history of the English race, and, if there is time for anything more, this suggestion in the pamphlet from which I have been quoting deserves attention: "To make amends for abandoning the study of Latin and Greek authors, an affectionate look into the life of antiquity should be taken. Besides reviewing historically the literature and civilization of the ancients, good translations of the classics should be diligently and spiritedly read and explained, in order that the vanished interest may be recalled, and that the now qualified pupil may be spurred on to take the optional instruction in the Latin and Greek languages in the upper classes, and tread the path to the original sources."

Those who can spare time for these studies are to be congratulated, as are those who have the opportunity to study the history of the fine arts, or Egyptology. But as "flowers out of place" are called weeds, so the study of antiquity becomes noxious when it crowds more beneficial studies. An additional instance of such crowding is contained in the following:

"It is passing strange that, during the long period of their education, the rising generation should never hear an earthly syllable about the constitution and administration of their nation, about their own civil rights and duties, about matters of finance, etc. Of course, there is no time for this in a school in which the pupils learn exactly how the 'revenue-administration of the Athenians' was constituted, what salary a Roman judge received, and what share of his father's property the noble-born Attic youth was entitled to."

Much the same view was taken by Paul Pfizer: "The wisest peoples held the subject of education to be worthy of the most careful attention and the deepest reflection; but, since education has no longer any reference to the state and to public life, since the duty of the educator has been made merely to be at home in a world which perished long ago, and to take no cognizance of his native land, it has covered itself with the dust of the school, and assumed the color of the ridiculous and the pedantic."

Would not a boy who had completed the course just outlined be

prepared to enter upon the studies of a university? The number of those who firmly believe that substantially this course is the best for all boys up to the usual college age is rapidly increasing. They are active and in earnest, and are making their influence felt; but mark what they ask—not that all boys shall be required to take this training, but that boys so trained shall be admitted to equal privileges with those trained in the old way. They would put the two methods squarely side by side, confident of the survival of the fittest. Those defenders of the classics who would anticipate a decline in the study of Greek and Latin under these conditions, have little faith in the justness of their own claims.

ORIGIN OF THE SYNTHETIC PHILOSOPHY.*

By HERBERT SPENCER.

To the Editor of the Times.

SIR: As you have placed before a multitude of readers Mr. Frederic Harrison's anniversary address on "The Memory of Auguste Comte and his True Works," I may, I think, properly ask you to place before the same readers the disproof of a statement made by Mr. Harrison which gravely compromises me. He said that "Mr. Herbert Spencer, who had written a book to explain his divergences from Comte, was himself in all essentials his unconscious imitator, 'Synthetic Philosophy' being nothing but an attempt to play a new tune upon Comte's instrument. All the *idées-mères*, as the French said, of the Synthetic Philosophy, were those of the Positive Philosophy. Had there been no Comte, assuredly there would have been no Spencer." Even had I no other motive than that of showing my independence of Comte, I should, I think, be justified in not allowing this statement to pass unchallenged. But I have a further motive. As I have recently been passing a very outspoken judgment on the absurdities of the Comtean religion, the above passage implies that I have been ridiculing a man to whom I am deeply indebted, and the desire to clear myself from this aspersion compels me to speak.

A reader of literary history, struck as he must be with the numerous disputes about originality and priority, might sum up the result in somewhat Irish fashion by saying—No man's ideas are his own; they always belong to somebody else. My experiences might serve to support his paradox. Three distinct origins have been assigned for the Synthetic Philosophy. The current belief is that I have simply accepted Mr. Darwin's doctrine, and occupied myself in giving to it a wider extension; the truth being that the essential principles of the Synthetic Philosophy were set forth by me in two essays on "Progress:

* From the "Times" of September 9, 1884.

its Law and Cause," and on "The Ultimate Laws of Physiology," published respectively in the "Westminster Review" and the "National Review" (not the periodical now bearing that title) in April and October, 1857, more than two years before the publication of "The Origin of Species." Another source was not very long since alleged by the Rev. Thomas Mozley. In his "Reminiscences," etc., when giving an account of the influence exercised over him by my father, of whom he was a pupil, he describes himself as deriving from my father certain ideas which led him to think out a philosophy of like general nature with that set forth by me; but when, after enumerating the cardinal ideas of the Synthetic Philosophy, I requested him to point out any one of them which was contained in his own "elder philosophy," as he called it, he did not do so, and said all he meant by "family likeness" was such family likeness as might be alleged between "Cardinal Newman's view and his brother Frank's."* And now comes Mr. Harrison, repeating the assertion made twenty years ago, and then refuted by me, that I am indebted to Comte—nay, that I owe to him "all the *idées-mères*" of the Synthetic Philosophy. These three different beliefs concerning its origin go a long way toward destroying one another. Each by implication contradicting the other two is itself contradicted by them; and being thus severally discredited, they might, perhaps, safely be left as they stand. But readers of Mr. Harrison's address might not consider this sufficient, and I must therefore deal with his statement directly.

In the first sentence of that statement he refers to a *brochure* entitled "The Classification of the Sciences; to which are added Reasons for Dissenting from the Philosophy of M. Comte," originally published in March, 1864. In this I have set down not such "divergences" as might consist with partial acceptance, which Mr. Harrison's statement may lead readers to suppose, but I have given "reasons for dissenting from," and rejecting, Comte's philosophy altogether. I have enumerated six cardinal propositions essentially characterizing the Positive Philosophy, and have set against them six counter-propositions which I hold. I have then gone on to say:

"Leaving out of his 'Exposition' those pre-established general doctrines which are the common property of modern thinkers, these are the general doctrines which remain—these are the doctrines which fundamentally distinguish his system. From every one of them I dissent. To each proposition I oppose either a widely different proposition or a direct negation; and I not only do it now, but have done it from the time when I became acquainted with his writings. This rejection of his cardinal principles should, I think, alone suffice; but there are sundry other views of his, some of them largely characterizing his system, which I equally reject."

And I have thereupon contrasted four other general views of Comte with the opposite views held by me.

* See "Athenæum," July 22, 1882.

But I do not write this letter merely for the purpose of pointing out these facts. I write it mainly for the purpose of making public the judgment given on the question at issue by the earliest and most distinguished of M. Comte's English adherents, Mr. John Stuart Mill. Before quoting his judgment I must explain how it came to be given, and in doing this must reproduce a letter written by me to him many years ago, which itself contains evidence clearly disproving Mr. Harrison's assertion. Here it is, or rather the first part of it:

"17 WILMOT STREET, DERBY, *July 29, 1858.*

"MY DEAR SIR: May I ask your opinion on a point partly of personal interest, partly of more general interest?

"In the essays on 'Progress; its Law and Cause,' and on 'Transcendental Physiology,' which I believe you have read, are the rudiments of certain general principles, which, at the time they were first enunciated, I had no intention of developing further. But more recently these general principles, uniting with certain others, whose connection with them I did not before recognize, have evolved into a form far higher than I had ever anticipated; and I now find that the various special ideas which I had designed hereafter to publish on certain divisions of Biology, Psychology, and Sociology, have fallen into their places as parts of the general body of doctrine thus originating. Having intended to continue occupying myself, as hitherto, in writing essays and books embodying these various special ideas, I have become still more anxious to devote my energies to the exposition of these larger views, which include them, and, as I think, reduce all the higher sciences to a rational form."

Has Mr. Harrison any doubt concerning the truth of these statements? If so, he may easily verify them. If he will turn to the second, or constructive, division of "First Principles" (I give the references to the second and subsequent editions, partly because they are most widely distributed), he will find that Chapter XV embodies the argument contained in the first half of the essay on "Progress: its Law and Cause," and incorporates all the illustrative examples along with additional ones; and in Chapter XX he will find the second half of that essay reproduced with all its illustrations, and with further elaborations. Similarly, two fundamental principles set forth in the essay originally published under the title "The Ultimate Laws of Physiology" (but republished in the third volume of my *Essays, etc.*, under the title "Transcendental Physiology"), he will find are severally developed in Chapters XIV and XIX; where, again, the original illustrations will be found joined with numerous others, accompanying a much wider extension of those principles. In these two essays, then, Mr. Harrison will discover the *idées-mères* of the Synthetic Philosophy; and the task before him is to affiliate these ideas, if he can, upon the ideas contained in the Positive Philosophy.

I now come to the opinion expressed by Mr. Mill. When, in 1864, there appeared in the *Revue des Deux Mondes* an article on "First Principles," by M. Auguste Laugel, in which he described me as being

in part a follower of M. Comte, and when I decided to append to "The Classification of the Sciences" the "Reasons for Dissenting from the Philosophy of M. Comte," proving that M. Laugel's belief was erroneous, I bethought me of the above partially-quoted letter. On stating to Mr. Mill why I wanted it, he kindly returned it (not, however, soon enough for use), and with it there came a letter from himself. I give this letter, or rather the first paragraph of it—a paragraph which, under ordinary circumstances, it would be bad taste in me to publish, but which, under the present circumstances, I shall, I think, be held justified in publishing:

"BLACKHEATH, *April 3, 1864.*

"DEAR SIR: I am fortunately able to send you the letter you want. No Englishman who has read both you and Comte can suppose that you have derived much from him. No thinker's conclusions bear more completely the marks of being arrived at by the progressive development of his own original conceptions; while, if there is any previous thinker to whom you owe much, it is evidently (as you yourself say) Sir W. Hamilton. But the opinions in which you agree with Comte, and which, as you truly observe, are in no way peculiar to him, are exactly those which would make French writers class you with him; because to them, Comte and his followers are the only thinkers who represent opposition to their muddy metaphysics."

To this I may fitly add a passage contained in Mr. Mill's work, "Auguste Comte and Positivism," issued a year later, in which, distinguishing between that part of the Positive Philosophy which belongs to Comte and that which "is the common inheritance of thinkers," he says: ***

"Mr. Spencer rejects nearly all which properly belongs to M. Comte, and in his abridged mode of statement does scanty justice to what he rejects" (p. 5).

Now, considering that Mr. Mill was a profound admirer of M. Comte, kept up a correspondence with him, and raised funds to support him, and considering that when the above letter was written I knew Mr. Mill personally only through two calls at the India House, and was an antagonist of Comtean views which he accepted, and had publicly combated one of his own views, it is manifest that any bias he may be supposed to have had was against me rather than for me. Such being the case, most persons will, I think, regard his voluntarily-given opinion as decisive. HERBERT SPENCER.

ATHENÆUM CLUB, *September 8th.*

Mr. Harrison replied to the foregoing letter, which elicited the following rejoinder from Mr. Spencer:

*To the Editor of the Standard.**

SIR: I regret further to occupy attention with a matter mainly personal, but feel obliged to do so.

* From the London "Standard" of September 15, 1884.

I pointed to the essays in which were contained the *idées-mères* of the Synthetic Philosophy, and gave Mr. Harrison means of finding that they were undeniably such by referring him to parts of "First Principles," in which they were developed; and I then invited him to point out the ideas in the Positive Philosophy from which they were derived. Instead of taking this direct way of establishing filiation, he has sought to establish it in various indirect ways.

He contends that I owe the conception of a "coherent body of doctrine," formed by "the amalgamation of Science, Philosophy, and Religion," to Comte. If he will turn to the Essay on "The Genesis of Science," he will see that my criticism of Comte's Classification of the Sciences is preceded by a criticism of the schemes of Oken and Hegel, both of which profess to be coherent bodies of doctrine formed of Philosophy and the Sciences. Having the three schemes before me, why does Mr. Harrison suppose that Comte, rather than Hegel or Oken, gave me the idea? And why should I not say that Comte was indebted to them, just as others say he was indebted for his *idées-mères* to St. Simon?

He refers to my first work, "Social Statics," as being identical in title with one by Comte. In the pamphlet issued twenty years ago, discussing the question now again raised, I stated that at the close of 1850, when "Social Statics" was published, Comte was to me but a name. It seems that Mr. Harrison did not believe me. There are various proofs, however. Though I have letters showing that "Social Statics" was not the title originally intended, this evidence must be left out, being too long to quote. But there is the sub-title, "The Conditions Essential to Human Happiness Specified, and the First of them Developed." Does this correspond with the substance of Comte's "Social Statics"? Further still, there is the fact, named in the pamphlet above mentioned, that I was blamed by a reviewer of "Social Statics" in the "North British Review" (August, 1851) because I did not "seem to have the slightest notion" of that which Comte understood by Social Statics. And, once more, there is the fact that the ideas and spirit of the book are as utterly alien to those of Comte as can well be. They involve a pronounced individualism, which was one of his aversions.

Because Comte here and there speaks of "synthesis," Mr. Harrison thinks that the title Synthetic Philosophy was derived from him. If he will refer to the programme as originally given, and as continued for ten years or more, he will see that no such title was used. My adoption of it was due simply to the fact that there had been given to the system by my American adherent, Mr. Fiske, the title "Cosmic Philosophy"—a title which I disapproved.

Mr. Harrison says, "Mr. Spencer has written volumes about the 'Social Organism,' 'Social Evolution,' 'Social Environment'; so has Comte." I did not know Comte had used the phrase "Social Organ-

ism"; but if Mr. Harrison will refer to "Social Statics," p. 443 and p. 453, he will find it used at a time when, as I have said, Comte was to me but a name. If Mr. Harrison alleges that anybody who writes about Social Evolution (in past days called Social Progress) must be indebted for the idea to Comte, he is simply illustrating afresh that which all observers are now remarking, that he and his co-disciples find Comte everywhere. As to "Social Environment," I have, I believe, occasionally used the expression; but it makes so little figure that I should be puzzled where to look for it. That the name Sociology was introduced by Comte is doubtless true, and that I have avowedly adopted it is also true: true also that I have been blamed for using this hybrid word. But though the word is his, the idea is not. In its crude form it can be traced as far back as Plato; and long before the time of Comte it assumed a considerable development in the work of Vico—"Scienza Nuova."

"The conception that all things social are amenable to invariable laws and have modes of life analogous to those of physical organisms is one of the most transcendent steps taken in modern thought," says Mr. Harrison. To the first of these statements I have to reply, that if Mr. Harrison will refer to a pamphlet on "The Proper Sphere of Government," written by me when twenty-two, he will find this same conception distinctly expressed and argued from. And to the second I have to reply, 1. That the analogy between the individual organism and the social organism is traceable in Greek thought; and, 2. That it was set forth elaborately, though very erroneously, by Hobbes. To say that "Comte is the unquestioned author of the thought" illustrates afresh the way in which his disciples are possessed by him.

The adoption of the word "Altruism" from Comte is referred to by Mr. Harrison. Here he is perfectly right. I have acknowledged the adoption; and I have also defended it as a very useful word.

Mr. Harrison claims for Comte the distinction between the militant phase of social life and the industrial phase. Is he sure that no one recognized it before? But that I do not owe the conception to him is again sufficiently shown by reference to "Social Statics," pp. 419–434 (original edition), where the essentially different traits of predatory societies and peaceful societies are contrasted, though the words "industrial" and "militant" are not used. Moreover, Comte's conception and mine, respecting the types of social organization proper to the two, are radically opposed.

In the "Principles of Biology," vol. i, p. 74, is a note which, by implication, refutes the statement that I owe the definition of life to Comte. Comte evidently made in the "Positive Philosophy" an approach to the truth, but he strangely missed it. How little he himself regarded what he there said as a definition of life is proved by the fact that he adopted De Blainville's definition. Dr. Bridges says he

reached it in the "Politique Positive." Be it so. That, however, is a work which Mr. Harrison reproaches me with not having read.

But if I go on in this way, meeting one by one Mr. Harrison's allegations, I shall tire your readers before I reach the statement which I think will be held conclusive. My course must be to specify those *idées-mères* which I have indicated to Mr. Harrison, but which he refuses to look for, and then to show how from these the whole doctrine I have set forth gradually grew.

Omitting earlier stages, which I can trace back to 1850, I begin with the essay, "Progress: Its Law and Cause," which was published in 1857. On the second page of that essay I have named the generalization reached by Von Baer, that the changes undergone during the development of every living thing "constitute an advance from homogeneity of structure to heterogeneity of structure." On the next page I have enunciated the thesis of the essay; namely, that "this law of organic progress is the law of all progress"—not progress in a limited sense, but progress inorganic as well as organic, presented throughout the universe, from celestial bodies to such social products as science, art, and literature. How was the evidence supporting this thesis to be presented? By taking the various groups into which all kinds of phenomena are divisible, and showing that the law holds throughout each group, I have arranged them in the order astronomical, geological, biological, psychological, sociological. Why this order? The reasons are obvious. If the Cosmos has been evolved, then, in order of time, astronomical phenomena preceded geological, geological preceded biological, biological preceded psychological, psychological preceded sociological. Equally was the arrangement dictated by order of dependence. The existence of each of these groups of phenomena made possible the existence of the succeeding group. I could not have put the groups in any other order without manifest derangement. The second half of the article first asks the question—Why does this universal transformation go on? and the alleged cause is that "every active force produces more than one change" or effect; the implication being that there is a continuous multiplication of effects, of which increasing heterogeneity is a result. The rest of the article traces out everywhere this multiplication of effects; and in thus interpreting deductively the previous inductions I was, of course, forced to follow the same succession of groups of phenomena by the necessities of orderly exposition.

Is there anything here attributable to M. Comte? This order of exposition, which arose irrespective of any classification of the sciences, Comtean or other, and which governs the order in which the works constituting the Synthetic Philosophy have been written, is one which Mr. Harrison is courageous enough to say corresponds with Comte's scheme of the sciences. He does this in face of the fact that of Comte's six sciences three have no place in it! It contains no di-

vision dealing with mathematics, none with physics, none with chemistry!

I pass on now to point out that six months after, in the second essay I named, there is recognized the fact that for this universal transformation of things there is a cause taking precedence of the multiplication of effects, namely, the instability of the homogeneous (i. e., the relatively homogeneous, for absolute homogeneity does not exist)—a law which holds alike of a nebulous mass, an ovum, a primitive tribe, etc. And then in the same essay the law of integration (previously recognized in 1855 in the "Principles of Psychology," Part III, chapter xiv), is set forth as holding of organisms and societies—a law later recognized as holding of all evolving aggregates, and eventually recognized as the primary trait of all evolution. Are these conceptions to be found in the Positive Philosophy?

Shortly after, further developments of these views took place, which are referred to in my letter to Mr. Mill already quoted. Then came recognition of the truth that in aggregates of all orders one of the traits of evolution is increase of definiteness; universally the tendency is for the differentiated parts, at first vaguely marked out, to become sharply marked out. Later still was recognized the fact that these various changes are accompanied everywhere by a process of segregation; and then, finally, in answer to the question, What is the outcome of all these changes? there was reached the answer—They inevitably continue till an equilibrium of forces is reached; every aggregate, inorganic or organic, goes on changing until the forces acting upon it are balanced by the forces it opposes to them; hence the general law of equilibration. Are these Comtean conceptions?

When in 1860–'62 "First Principles" was written, these several inductive and deductive generalizations were incorporated in a coherent theory; and in the chapter dealing with each, there was followed this same order in the groups of illustrations which I have shown naturally arises. Beyond this, however, there was an endeavor to go behind these proximate causes of the universal transformation, and find the ultimate cause. This was alleged to be the persistence of force (an expression I continue to use as comprehending both the conservation of energy and the constancy of those forces by which passive matter becomes known to us). Has Comte enunciated these ideas, or any allied to them?

Lastly, I have to point out that only in the reorganized second edition of "First Principles," published five years later, when, along with other developments, there was recognized that transformation of motion which everywhere accompanies the transformation of matter, did the general conception reach its complete form. There was a gradual growth, as Mr. Mill says; and it had continued from 1850 to 1867. Not only has Comte's influence no place whatever in this process, but the ultimate product of it has no alliance whatever with

the product he calls Positive Philosophy. For what is the one word which describes this theory of transformation, exhibited by the Cosmos as a whole and by every part of it, and proceeding everywhere after the same general manner and everywhere consequent on the same general laws of forces? The one word is Cosmogony. And what is the name applicable to M. Comte's Positive Philosophy? An Organon of the Sciences.

See, then, how the case stands. A system which had for its germinal idea Von Baer's formula of organic development—a system which grew by the addition of other general ideas, to one of which, I believe, Schelling's doctrine of individuation partially opened the way, but the others of which grew up I know not how—a system which slowly became a coherent whole, uniting the several principles by derivation from one ultimate principle—a system the exposition of which followed an order not determined by any theory of classification, but simply by the order of genesis of the phenomena themselves—a system which, at the very outset, presented itself as the rudiment of a cosmogony, and became eventually a fully-elaborated cosmogony; is a system which Mr. Harrison holds to be inspired by Comte's "Organon of the Sciences," the greater part of which is concerned with scientific methods, with the dependence of ideas, with the course of intellectual progress, with the order of discovery, and the like; and which entirely ignores geological evolution, biological evolution, and psychological evolution. This system it is which Mr. Harrison characterizes as "an attempt to play a new tune upon Comte's instrument"!

I ask space only for a few words on the question of authorities. Mr. Harrison, finding the verdict of Mr. John Stuart Mill against him, does his best to discredit it. He says that Mr. Mill was scarcely in a position for judging, since "he had one volume only and part of another before him." He is quite mistaken. If I had continued to quote Mr. Mill's letter, I should have quoted a passage saying that he had been re-reading the "Principles of Psychology" (edition of 1855). Besides this, and "Social Statics," and "First Principles," and nearly one volume of the Biology, he had before him two volumes of Essays, the majority of which bear in one way or other on the doctrine of evolution, and sufficiently show the drift of much that was coming. But Mr. Harrison attempts to discredit Mr. Mill's letter by calling it a "testimonial," and saying that he was able to "read between the lines." After having pointed out that I simply asked Mr. Mill to return my letter, and that his letter, accompanying it, was voluntarily written, I think every one will be of opinion that this sneer of Mr. Harrison's is wholly uncalled for; and when they observe that he says what he does notwithstanding that Mr. Mill, in his volume on Comte published a year later, utters substantially the same opinion as in his letter, they will think his sneer without excuse. To strengthen his case Mr. Harrison seeks to override the verdict of Mr. Mill by that of

Mr. Lewes—ranks Lewes higher than Mill as an authority in philosophy! I imagine the raised eyebrows of competent judges.

Here I leave the matter. I have nothing more to say than that if any one has doubts he may easily settle them, irrespective of the explanation I have given above, and irrespective of any authority. He will see that alike by its position as first of the series, and by its title, "First Principles" is shown to contain the cardinal ideas elaborated in the volumes following it. Let him, then, take this volume and take also Miss Martineau's abridged translation of the Positive Philosophy, and compare the two. After an hour's search for points of community he will, I think, feel astonished that any one should have asserted a connection between them.

I am, sir, your obedient servant,

HERBERT SPENCER.

ATHENÆUM CLUB, *September 15th.*

THE FUTURE OF THE NEGRO IN THE SOUTH.

BY JAMES B. CRAIGHEAD.

THE term "mud-sill" is supposed to be used contemptuously in the Southern States to designate the lowest rank of the people: those who use nothing and have nothing to use but muscle for their maintenance; men who are uneducated and indifferent to education; men without other aspiration or ambition than that which incites them to appease their hunger and to ward off the blasts of winter. Under every form of government, despotic, monarchal, or republican, such class, more or less depraved, must necessarily exist, and the question in the Southern States is, What shall be the color of the mud-sill? or, if the colors be assorted, white, black, and yellow, shall we have different orders of mud-sills based on colors? The position is open to competition, to all shades of color, to whichever is willing to take it, or most reluctant to strive for anything higher or better.

The Executive war decree of emancipation fell on the South at a time when, owing to the manly front presented by the Confederate forces, it was generally regarded by the Southern people as mere *brutum fulmen*. Even in cities which had succumbed to Federal arms, and were garrisoned by national troops, the proclamation was regarded by the citizens simply as a threat; these latter looked forward to a rapid advance of the Southern armies, and had no doubt of final victory. Hence they submitted to the increasing rebelliousness of their slaves, just as they submitted to the military requirements of post-officers, provosts, etc.—a mere temporary annoyance, not only soon to be got rid of, but to be heavily atoned for. In the sparsely settled rural regions the news came slowly, and was at first, to the ordinary

negro mind, incomprehensible; nevertheless, it gradually permeated his brain that, should the Federal arms prevail, he would be free. But would the North prevail? Every man in the circle of his acquaintance in whom had heretofore resided authority hooted at the idea; the possibility of the South being conquered was openly scouted, and the effect of this on the negro's intelligence was to warn him to submission. Here and there, one more adventurous than the rest ran away and hid himself behind the Federal lines, but ninety-nine out of a hundred not only remained in bondage, but openly ridiculed the idea of their preferring to be free: the old farm and the old master were good enough for them. Of these a small percentage were sincere, as was proved by their remaining at home and serving their former owners after the necessity for so doing had ceased, just as if no edict had been issued; but in time the last one deserted, even the octogenarians, who set up their separate establishments, when they could, with a parting declaration to their old masters that so long as they were able to support themselves they would do so, but after that they proposed to return and be maintained as were the aged in times of slavery.

To the unreflecting white man it seemed as if chaos had come again; nothing like this had ever before come under the limited range of his reading or experience. To the student it was but a repetition of history; to him, beyond the loss of so much personal property, and the delay in the readjustment of social laws, no great cataclysm had occurred or was to be apprehended. Before emancipation, the negro had to work or be lashed; now, he has to work or to starve. Before the war, the owner was obligated to furnish the slave with provisions and clothing, to pay his doctor's bills when sick, to maintain him in idleness when superannuated, to bury him when dead. Under the new *régime* the freedman must do all these things and make these provisions for himself. The intelligent Southern man was prepared to pocket his losses and to go to work under the new order of affairs, but was met at the very beginning with obstacles. The poor emancipated slave had an idea that liberty meant license: all his life he had seen free white people living a life of, what appeared to him, perfect idleness, and his thought was to reach that blissful condition: he was willing to labor only sufficiently to supply himself with meat and clothes, and it really appeared that the South, instead of selling, as it now does, the produce of a single crop to the value of over three hundred million dollars, would sink into a semi-barbarous condition, with a population (all the enterprising ones having removed) satisfied with just enough to prevent absolute want. And thus it might have been but for the *vim* and determination of the Anglo-Saxon people, who foresaw that, if but small crops were made, large prices would be obtained. Their example has told among the blacks, especially the men; the women have yet to learn; the example of white ladies, who lived luxuriously before the war, now doing a great part of their own

labor and drudgery, instead of being an example to the former slave women, only affords a gratification to their spite and malevolence.

The freedman imagined that whatever superiority white people have over the blacks is owing to education; and as Eve was induced to think that if she and Adam should eat of the forbidden fruit they would be as gods, so the ordinary African thought if his child could only read, write, and cipher, he would be in every way the equal of the Caucasian. He was utterly unable to discriminate between a man with only capacity to fill with infinite labor a postal card and one who could reason out the law of gravity or define the principles of electricity. With this glorified idea on the subject of education, their enthusiastic desire for schools is not surprising. Their only idea of the difference between Prospero and Caliban was, that one could read and write and the other could not.

However absurd these views were, and however great the disappointment which follows, the result is good. If the entire race could read, write, and cipher, it would be an excellent thing. An utterly uneducated man, unless he chances to be of extraordinary acuteness, is at the mercy of one who is learned; the latter may assert that twice twenty are fifty, and the ignorant man, unable to disprove the assertion, submits. Enough education to enable a laboring-man to calculate the amount of his wages, and to verify the entries and summing of his pass-book, is necessary to prevent his being cheated by unscrupulous men. A vast number of the colored people are now educated to that extent, with great advantage to the better understanding between employer and employé. If the latter can comprehend simple accounts, there will be little difficulty in the settlement of his wages; but it is difficult to explain figures to the ignorant man, who, in most cases, imagines himself defrauded, simply because he can not comprehend. Persons who have to do with working-men, white or black, will readily agree that there is tenfold more trouble in adjusting accounts with those who are illiterate than with those who have even rudimental education.

The opportunities of the blacks for obtaining education in the South are abundant, greater, indeed, in many places than those in reach of the whites. In the State wherein the writer resides, each county is divided into school districts of convenient size, each with self-contained power of subdivision, under certain conditions: these districts are autonomous under general State laws; they decide for themselves, by popular vote, the amount of tax they are willing to pay respectively for the purpose of education, which tax is collected by the revenue collector as other taxes are; they elect each three directors to manage the scholastic affairs and funds, selection of teachers, etc. In vast numbers of these districts the blacks largely outnumber the whites, and elect not only magistrates, constables, etc., but also school directors, and in school matters the white element is utterly disregarded, except

in the matter of taxes. In the sparsely settled districts the amount of annual tax (limited to five mills) will permit of but one school, and that with a session of not more than four or five months each year, and herein lies the trouble. The black directors, knowing that but one school can be maintained, are willing to employ a white teacher and call it a white school provided their children are allowed to attend, or they will make it a black school, and white children may share the advantages. White prejudices, which none but a Southerner can understand or appreciate, render each of these offers unacceptable and repulsive, and it is difficult to blame the freedmen that they avail themselves of the power which the law has given them, and employ colored teachers. Things may be better regulated after a while; in the mean time the negroes are gradually acquiring education, while in many places the whites remain without schooling, or with but little.

If the African brain were as large and as active as that of the Caucasian, the result of this condition of affairs could be easily calculated, for, notwithstanding the preponderance of authority which centuries of domination have given to the white race, it is much to be doubted if the conditions would not be reversed if, with equal natural capacity, an educated colored race should oppose illiterate whites; but, fortunately for the latter, two things stand in the way of such absolute subversion of positions: First, it is indisputable that, as a race, the African is inferior to the Caucasian in intelligent comprehensive reasoning and constructive power, and it would require something besides mere intellectual improvement to bring the former up to the level of the latter. Second, the colored man has to-day a strong desire that his children shall be educated, though he is willing to make but few personal sacrifices for that object. To be sure, he votes taxes for the purpose, but, as he pays his proportion indirectly, he does not feel them. The desire is entirely predominated by his determination that they shall, at as early an age as possible, become workers, and thereby relieve his shoulders of a large part of his necessary labor. Consequently he is unwilling to allow much time to schools. So soon as the child is able to wield a hoe he is regarded a fractional field-hand, and during the cotton-picking season quite a large fraction. He knows nothing, it is not in his nature to know anything, of that vigorous Anglo-Saxon determination which, under the circumstances described, cheerfully pays the school-tax, and then makes personal sacrifices in order that the children may be sent to some pay-school. The desire of the African parent that his child shall work is so strong that it is safe to say that, with few exceptions, the young negroes of to-day, especially those on farms, live under more severe rules as to labor than their fathers did while children in slavery, with the reasonable consequence that the young African, as soon as he finds himself capable of self-support, quits forever the paternal roof which appears to him precisely as slavehood appeared to his ancestors.

Much has been written of late years concerning the condition of morality among the emancipated people, but little in extenuation thereof. During the existence of slavery, the status of married life among the blacks, especially among those of the rural districts, was much higher and more respectable than it is now. Slave-owners for sanitary and police reasons required a certain amount of conjugal fidelity. In all cases masters were consulted as to marriage alliances, and in most cases insisted that the ceremony should be performed in a public manner either by a magistrate or a minister of the gospel with all the formality that obtained among the whites. Conjugal fidelity was insisted on and enforced, if need be, by punishment. Man and wife finding themselves bound together by an indissoluble tie, did as the more intelligent of other races do, made the best of their bonds and lived harmoniously. This is all changed. After the war, the highest courts of the country decided that as matrimony is a civil contract and as slaves could not make legal contracts, *ergo*, no marriage entered into in a state of bondage was valid or could be enforced. The result of this correct but unfortunate decision was, that every former slave who lusted after a new and younger wife put aside the old one. The young married negroes, seeing this free-and-easy way of upsetting domestic arrangements, and without caring for the reason thereof, availed themselves of the first domestic quarrel to separate and select new partners. The newly separated, if continuing in the same neighborhood, did not of course marry other wives, but lived in concubinage; but, if they removed to other States, they did not hesitate to marry again. If the crime of bigamy were followed by sure punishment, there would not be penitentiaries enough in the South to hold the guilty of a single State. The colored people do not appear to see the viciousness of this condition of affairs; and the white people, grand juries included, do not care to take the matter up, and so it continues.

A great fault of the negro is a lack of veracity. It may be safely ventured that there is not a magistrate, judge, or lawyer in the South who will assert that the statements of negroes, especially of those out of cities, are to be relied upon. To be sure, there are many honorable exceptions, but it is a race characteristic. Many hesitate to tell a direct falsehood, but there are but few who will not lie constructively in concealing the truth. It is hard to condemn them. In times of slavery their only safety from deserved punishment was concealment and by lying out of the difficulty, assisted by the concurrent testimony of friends. The habit descends from father to child. The first lesson taught a colored child as soon as it is able to comprehend the lesson is, "If the white folks ask you anything, always answer, 'I don't know.'" Absolute ignorance, even if assumed, is safer than a manufactured lie. Often I have known a colored parent to chastise her child unmercifully for answering truthfully some simple question

of no importance whatever, only that it was a white person who was the questioner. These parents will not learn that a child taught systematically to lie to others will lie to them, and any detected prevarication with them is in the same way cruelly punished; and, as the ignorant never punish except when in a rage, it is safe to say that the life of the young darkey is not a pleasant one.

The peculiarities and monstrosities of African religion (so called) have been too often described to require many words here. In the cant of the present time, a number of Protestant denominations, each at war with the others, assume and allow to the others the title "orthodox." It is difficult for a layman to understand how twenty different bodies all teaching different faiths can all be orthodox, but so it is, and under this ruling the various African churches are all orthodox. How far are the vices, described as appertaining to the race, modified by religion? Not much. With the ordinary African religion is not a matter of doing, but entirely a matter of feeling. If one of them, after spending an entire week in vicious living, can only get up a certain amount of enthusiastic feeling during the shouting, howling, and dancing of a Sunday-night meeting, he feels that his soul is washed and that it is spotless as snow. It is the same ratiocination that convinces every convicted negro murderer that he will ascend directly from the gallows into heaven. Other more phlegmatic sinners may be compelled to wait for the judgment-day, but for him the gates of heaven stand wide open. When pardon follows sin so rapidly, it is not to be wondered at that he is ready to fall again to-morrow.

What has been written of the African people in this paper has in view those who live in the country and have but limited intercourse with minds superior to their own; a class of people who, if left to themselves, would degenerate rapidly into barbarism. But for the small leaven of more intelligent whites, the black people would soon be victims of *voudoo*. Indeed, it is hard to find a rural community in the South where that dreadful bugbear is not more or less believed in and feared. Often a stupid, uneducated negro secretly dominates an entire neighborhood by virtue of a self-assertion that he possesses mystic powers, and an obscure hint of a dirty little bag of miscellaneous abominations carries far more terror than ever did overseer's whip. I may defy the magician's power and openly submit myself to his supernatural malevolence, but it will do but little toward assuaging the fears of the negroes, who agree that the spells have no power over another race.

I have never had the craze of enforced education or enforced temperance; all the same, I shall be glad to see the colored people as well as the whites educated: not in high-schools, with a view of deluging the country with school-teachers, but to the extent of giving every child a good common-school education. In my official character as school director (to which office I was once elected simply because

there were but two colored men in the district who could read and write, and the law requires three officers), I have received a number of written applications for the position as teacher, some from graduates of normal schools and universities (?), all with examiners' certificates of ability, etc., but I do not remember seeing any one of these applications which was grammatically expressed or orthographically correct. Still, as the applicants were capable of teaching the rudiments of education, these trifling defects were never permitted to stand in the way of their employment. It is not asserted that all the graduates of these normal schools and universities are equally deficient; it is quite probable that the better sort find places in cities, while the country must content itself with what is left.

The social problem in the South does not so immediately concern the wealthy as it does the poor whites. The rich man can send his children to academies and colleges; he can seek society wherever it is congenial; but the poor man, tied to one spot, must be governed by circumstances beyond his control. At present the poor white and black people work together in the fields and shops and live on friendly terms without hitch or jar until the white asserts in some way his feeling of superiority, which, both being equal in means, education, and political power, is based on nothing more substantial than the mere color of the skin. Then the negro stands on his dignity, and is ready for combat. In peaceful neighborhoods, there is but little assumption of superiority, and it is only manifested in a silent way by the steady refusal of the white to permit his children to sit at school or in church with the children of the black; they may play together, work together, and treat each other as equals, until church or school is mentioned, and there the line is drawn. So long as this passive ostracism works his children no absolute evil, the negro, with his own schools and his own churches, cares nothing for it. It is perhaps vain speculation as to the future of this problem; only it seems certain that if the white children are not educated and taught refinements, and the black children are, it will be difficult in the future, even if desirable, to maintain any distinction of classes in the South, and especially any favorable distinction, which will be based on nothing more substantial than the absence of color in the epidermis, unless African nature is irredeemably bad; unless the vicious qualities attributed to him in this paper are irreparable, it is absolutely certain that, with the aids which now surround him, he will rise greatly in the scale of humanity, and a generous world will show its favor to the intelligent individual, no matter how black his skin, who has lifted himself out of the mire and contempt of centuries, rather than extend a helping hand to one who has had the fortune to be born of a higher race, but who proved unworthy of his lot.

Scientists and the world admit the natural superiority of the white races over the colored, and it seems incontrovertible that, with equal

ambition and equal excitement to exertion, the white will surely surpass the black in any and every condition of life, and in the exercise of every function of mind and muscle; and there can be no political chain strong enough to bind the white in a subordinate position, provided he will avail himself of the advantages which Nature has given him in the division of the races of humanity.

PENDING PROBLEMS OF ASTRONOMY.*

By Professor CHARLES A. YOUNG.

MR. PRESIDENT, Fellows and Members of the Association, Ladies and Gentlemen: Thirty-six years ago this very month, in this city, and near the place where we are now assembled, the American Association for the Advancement of Science was organized, and held its first meeting. Now, for the first time, it revisits its honored birthplace.

Few of those present this evening were, I suppose, in attendance upon that first meeting. Here and there, among the members of the Association, I see, indeed, the venerable faces of one and another, who, at that time in the flush and vigor of early manhood, participated in its proceedings and discussions; and there are others, who, as boys or youths, looked on in silence, and listening to the words of Agassiz and Peirce, of Bache and Henry, and the Rogers brothers and their associates, drank in that inspiring love of truth and science which ever since has guided and impelled their lives. Probably enough, too, there may be among our hosts in the audience a few who remember that occasion, and were present as spectators.

But, substantially, we who meet here to-day are a new generation, more numerous certainly, and in some respects unquestionably better equipped for our work, than our predecessors were; though we might not care to challenge comparisons as regards native ability, or clearness of insight, or lofty purpose.

And the face of Science has greatly changed in the mean time—as much, perhaps, as this great city and the nation. One might almost say that, since 1848, "all things have become new" in the scientific world. There is a new mathematics and a new astronomy, a new chemistry and a new electricity, a new geology and a new biology. Great voices have spoken, and have transformed the world of thought and research as much as the material products of science have altered the aspects of external life. The telegraph and dynamo-machine have

* Address of the retiring President of the American Association for the Advancement of Science, delivered at Philadelphia, September 5, 1884.

not more changed the conditions of business and industry than the speculations of Darwin and Helmholtz, and their compeers, have affected those of philosophy and science.

But, although this return to our birthplace suggests retrospections and comparisons which might profitably occupy our attention for even a much longer time than this evening's session, I prefer, on the whole, to take a different course; looking forward rather than backward, and confining myself mainly to topics which lie along my own line of work.

The voyager upon the inland Sea of Japan sees continually rising before him new islands and mountains of that fairy-land. Some come out suddenly from behind nearer rocks or islets, which long concealed the greater things beyond; and some are veiled in clouds which give no hint of what they hide, until a breeze rolls back the curtain; some, and the greatest of them all, are first seen as minute specks upon the horizon, and grow slowly to their final grandeur. Even before they reach the horizon-line, while yet invisible, they sometimes intimate their presence by signs in sky and air; so slight, indeed, that only the practiced eye of the skillful sailor can detect them, though quite obvious to him.

Somewhat so, as we look forward into the future of a science, we see new problems and great subjects presenting themselves. Some are imminent and in the way—they must be dealt with at once, before further progress can be made; others are more remotely interesting in various degrees; and some as yet are mere suggestions, almost too misty and indefinite for steady contemplation.

With your permission, I propose this evening to consider some of the pending problems of astronomy—those which seem to be most pressing, and most urgently require solution as a condition of advance; and those which appear in themselves most interesting or likely to be fruitful from a philosophic point of view.

Taking first those that lie nearest, we have the questions which relate to the dimensions and figure of the earth, the uniformity of its diurnal rotation, and the constancy of its poles and axis. I think the impression prevails that we already know the earth's dimensions with an accuracy even greater than that required by any astronomical demands. I certainly had that impression myself not long ago, and was a little startled on being told by the superintendent of our "Nautical Almanac" that the remaining uncertainty was still sufficient to produce serious embarrassment in the reduction and comparison of certain lunar observations. The length of the line joining, say, the Naval Observatory at Washington with the Royal Observatory at the Cape of Good Hope is doubtful, not to the extent of only a few hundred feet, as commonly supposed, but the uncertainty amounts to some thousands of feet, and may possibly be a mile or more—probably not less than a ten-thousandth of the whole distance; and the direction of the

line is uncertain in about the same degree. Of course, on those portions of either continent which have been directly connected with each other by geodetic triangulations, no corresponding uncertainty obtains; and as time goes on, and these surveys are extended, the form and dimensions of each continuous land-surface will become more and more perfectly determined. But, at present, we have no satisfactory means of obtaining the desired accuracy in the relative position of places separated by oceans, so that they can not be connected by chains of triangulation. Astronomical determinations of latitude and longitude do not meet the case; since, in the last analysis, they only give at any selected station the *direction of gravity* relative to the axis of the earth, and some fixed meridian plane, and do not furnish any *linear* measurement or dimension.

Of course, if the surface of the earth were an exact spheroid, and if there were no irregular attractions due to mountains and valleys, and the varying density of strata, the difficulty could be easily evaded; but, as the matter stands, it looks as if nothing short of a complete geodetic triangulation of the whole earth would ever answer the purpose—a triangulation covering Asia and Africa, as well as Europe, and brought into America by way of Siberia and Behring's Straits.

It is, indeed, theoretically possible, and just conceivable, that the problem may some day be reversed, and that the geodesist may come to owe some of his most important data to the observers of the lunar motions. When the relative position of two or more remote observatories shall have been precisely determined by triangulation (for instance, Greenwich, Madras, and the Cape of Good Hope), and when, by improved methods and observations made at these fundamental stations, the moon's position and motion relative to them shall have been determined with an accuracy much exceeding anything now attainable, then by similar observations, made simultaneously at any station in this hemisphere, it will be theoretically possible to determine the position of this station, and so, by way of the moon, to bridge the ocean, and ascertain how other stations are related to those which were taken as primary. I do not, of course, mean to imply that, in the *present state* of observational astronomy, any such procedure would lead to results of much value; but, before the Asiatic triangulation meets the American at Behring's Straits, it is not unlikely that the accuracy of lunar observations will be greatly increased. The present uncertainty as to the earth's dimensions is, however, a sensible embarrassment to astronomers, only in dealing with the moon, especially in attempting to employ observations made at remote and ocean-separated stations for the determination of her parallax.

As to the form of the earth, it seems pretty evident that before long it will be wise to give up further attempts to determine exactly what spheroid or ellipsoid *most nearly corresponds* to the actual figure of the earth; since every new continental survey will require a modi-

fication of the elements of this spheroid in order to take account of the new data. It will be better to assume some closely approximate spheroid as a finality; its elements to be forever retained unchanged, while the deviations of the actual surface from this ideal standard will be the subject of continued investigation and measurement.

A more important and anxious question of the modern astronomer is, Is the earth's rotation uniform, and, if not, in what way and to what extent does it vary? The importance, of course, lies in the fact that this rotation furnishes our fundamental measure and unit of time. Up to a comparatively recent date there has not been reason to suspect this unit of any variation sufficient to be detected by human observation. It has long been perceived, of course, that any changes in the earth's form or dimensions must alter the length of the day. The displacement of the surface or strata by earthquakes or by more gradual elevation and subsidence, the transportation of matter toward or from the equator by rivers or ocean-currents, the accumulation or removal of ice in the polar regions or on mountain-tops—any such causes must necessarily produce a real effect. So, also, must the friction of tides and trade-winds. But it has been supposed that these effects were so minute, and to such an extent mutually compensatory, as to be quite beyond the reach of observation; nor is it yet certain that they are not. All that can be said is, that it is now beginning to be *questionable* whether they are, or are not.

The reason for suspecting perceptible variation in the earth's revolution lies mainly in certain unexplained irregularities in the apparent motions of the Moon. She alone, of all the heavenly bodies, changes her place in the sky so rapidly that minute inaccuracies of a second or two in the time of observation would lead to sensible discrepancies in the observed position; an error of one second in the time, corresponding to about half a second in her place—a quantity minute, certainly, but perfectly observable. No other heavenly body has an apparent movement anywhere nearly as rapid, excepting only the inner satellite of Mars; and this body is so minute that its accurate observation is impracticable, except with the largest telescopes, and at the times when Mars is unusually near the Earth.

Now, of late, the motions of the Moon have been very carefully investigated, both theoretically and observationally; and, in spite of everything, there remain discrepancies which defy explanation. We are compelled to admit one of three things: either the lunar theory is in some degree mathematically incomplete, and fails to represent accurately the gravitational action of the earth and sun and other known heavenly bodies, upon her movements; or some unknown force other than the gravitational attractions of these bodies is operating in the case; or else, finally, the earth's rotational motion is more or less irregular, and so affects the time-reckoning and confounds prediction. If the last is really the case, it is in some sense a most discouraging

fact, necessarily putting a limit to the accuracy of all prediction, until some other unchanging and convenient measure of time shall be found to replace the "day" and "second."

The question at once presents itself, How can the constancy of the day be tested? The lunar motions furnish grounds of suspicion, but nothing more; since it is at least as likely that the mathematical theory is minutely incorrect or incomplete as that the day is sensibly variable. Up to the present time the most effective tests suggested are from the transits of Mercury and from the eclipses of Jupiter's satellites. On the whole, the result of Professor Newcomb's elaborate and exhaustive investigation of all the observed transits, together with all the available eclipses and occultations of stars, tends rather to establish the sensible constancy of the day, and to make it pretty certain (to use his own language) that "inequalities in the lunar motions, "not accounted for by the theory of gravitation, really exist, and in "such a way that the mean motion of the moon between 1800 and 1875 "was really less (i. e., slower) than between 1720 and 1800." Until lately, the observations of Jupiter's satellites have not been made with sufficient accuracy to be of any use in settling so delicate a question; but at present the observation of their eclipses is being carried on at Cambridge, Massachusetts, and elsewhere, by methods that promise a great increase of accuracy over anything preceding. Of course, no speedy solution of the problem is possible through such observations, and their result will not be so free from mathematical complications as desirable—complications arising from the mutual action of the satellites and the ellipsoidal form of the planet. On account of its freedom from all sensible disturbances, the remote and lonely satellite of Neptune may possibly some time contribute useful data to the problem.

We have not time, and it lies outside my present scope, to discuss whether, and, if so, how, it may be possible to find units of time and length which shall be independent of the earth's conditions and dimensions, free from all *local considerations*, cosmical, and as applicable in the planetary system of the remotest star as in our own. At present we can postpone its consideration; but the time must unquestionably come when the accuracy of scientific observation will be so far increased that the irregularities of the earth's rotation, produced by the causes alluded to a few minutes ago, will protrude and become intolerable. Then a new unit of time will have to be found for scientific purposes, founded, perhaps, as has been already suggested by many physicists, upon the vibrations or motion of light, or upon some other physical action which pervades the universe.

Another problem of terrestrial astronomy relates to the constancy of the position of the earth's axis in the globe. Just as displacements of matter upon the surface or in the interior of the earth would produce changes in the time of rotation, so also would they cause corre-

sponding alterations in the position of the axis and in the places of the poles—changes certainly very minute. The only question is, Whether they are so minute as to defy detection. It is easy to see that any such displacements of the earth's axis will be indicated by changes in the *latitudes* of our observatories. If, for instance, the pole were moved a hundred feet from its present position, toward the Continent of Europe, the latitudes of European observatories would be increased about one second, while in Asia and America the effects would be trifling. The only observational evidence of such movements of the pole, which thus far amounts to anything, is found in the results obtained by Nyren in reducing the determinations of the latitude of Pulkowa, made with the great vertical circle, during the last twenty-five years. They seem to show a slow, steady diminution of the latitude of this observatory, amounting to about a second in a century; as if the north pole were drifting away, and increasing its distance from Pulkowa at the rate of about one foot a year. The Greenwich and Paris observations do not show any such result; but they are not conclusive, on account of the difference of longitude, to say nothing of their inferior precision.

The question is certainly a doubtful one; but it is considered of so much importance that, at the meeting of the International Geodetic Association in Rome last year, a resolution was adopted recommending observations specially designed to settle it. The plan of Signor Fergola, who introduced the resolution, is to select pairs of stations, having nearly the same latitude, but differing widely in longitude, and to determine the *difference* of their latitudes by observations of the same set of stars, observed with similar instruments, in the same manner, and reduced by the same methods and formulæ. So far as possible, the same observers are to be retained through a series of years, and are frequently to exchange stations when practicable, so as to eliminate personal equations. The main difficulty of the problem lies, of course, in the minuteness of the effect to be detected; and the only hope of success lies in the most scrupulous care and precision in all the operations involved.

Other problems, relating to the rigidity of the earth and its internal constitution and temperature, have, indeed, astronomical bearings, and may be reached to some extent by astronomical methods and considerations; but they lie on the border of our science, and time forbids anything more than their mere mention here.

If we consider next the problems set us by the Moon, we find them numerous, important, and difficult. A portion of them are purely mathematical, relating to her orbital motion; while others are physical, and have to do with her surface, atmosphere, heat, etc. As has been already intimated, the lunar theory is not in a satisfactory state. I do not mean, of course, that the moon's deviations from the predicted path are gross and palpable—such, for instance, as could be perceived

by the unaided eye (this I say for the benefit of those who otherwise might not understand what "pernickity" creatures astronomers are); but they are large enough to be easily observable, and even obtrusive, amounting to several seconds of arc, or miles of space. As we have seen, the attempt to account for them by the irregularity of the earth's rotation has apparently failed; and we are driven to the conclusion, either that other forces than gravitation are operative upon the lunar motions, or else (what is far more probable, considering the past history of theoretical astronomy) that the mathematical theory is somewhere at fault.

To one looking at the matter a little from the outside it seems as if that which is most needed just now, in order to secure the advance of science in many directions, is a new, more comprehensive, and more manageable solution of the fundamental equations of motion under attraction. Far be it from me to cry out against those mathematicians who delight themselves in transcendental and *n*-dimensional space, and revel in the theory of numbers—we all know how unexpectedly discoveries and new ideas belonging to one field of science find use and application in widely different regions—but I own I feel much more interest in the study of the theory of functions and differential equations, and expect more aid for astronomy from it.

The problem of any number of bodies, moving under their mutual attraction, according to the Newtonian laws, stands, from a physical point of view, on precisely the same footing as that of *two* bodies. Given the masses, and the positions and velocities corresponding to any moment of time, then the whole configuration of the system for all time, past and future (abstracting outside forces, of course), is absolutely determinate, and amenable to calculation. But while, in the case of *two* bodies, the calculation is easy and feasible, by methods known for two hundred years, our analysis has not yet mastered the general problem for more than two. In special instances, by computations, tedious, indirect, and approximate, we can, indeed, carry our predictions forward over long periods, or indicate past conditions with any required degree of accuracy; but a general and universally practicable solution is yet wanting. The difficulties in the way are purely mathematical; a step needs to be taken, corresponding in importance to the introduction of the circular functions into trigonometry, the invention of logarithms, or the discovery of the calculus. The problem confronts the astronomer on a hundred different roads; and, until it is overcome, progress in these directions must be slow and painful. One could not truly say, perhaps, that the lunar theory must, in the mean while, remain quite at a stand-still: labor expended in the old ways, upon the extension and development of existing methods, may not be fruitless, and may, perhaps, after a while, effect the reconcilement of prediction and observation far beyond the present limits of accuracy. But if we only had the mathematical powers we long for,

then progress would be as by wings: we should fly, where now we crawl.

As to the physical problems presented by the moon, the questions relating to the light and heat—the radiant energy—it sends us, and to its temperature, are the most attractive at present, especially for the reason that the results of the most recent investigators seem partially to contradict those obtained by their predecessors some years ago. It now looks as if we should have to admit that nearly all we receive from the moon is simply *reflected* radiation, and that the temperature of the lunar surface nowhere rises as high as the freezing-point of water, or even of mercury. At the same time, some astronomers of reputation are not disposed to admit such an upsetting of long-received ideas; and it is quite certain that, in the course of the next few years, the subject will be carefully and variously investigated. Closely connected with this is the problem of a lunar atmosphere—if, indeed, she has any.

Then there is the very interesting discussion concerning changes upon the moon's surface. Considering the difference between our modern telescopes and those employed fifty or a hundred years ago, I think it still far from certain that the differences between the representations of earlier and later observers necessarily imply any real alterations. But they, no doubt, render it more or less probable that such alterations have occurred, and are still in progress; and they justify a persistent, careful, minute, and thorough study of the details of the lunar surface with powerful instruments: especially do they inculcate the value of large-scale photographs, which can be preserved for future comparison as unimpeachable witnesses.

I will not leave the moon without a word in respect to the remarkable speculations of Professor George Darwin concerning the tidal evolution of our satellite. Without necessarily admitting all the numerical results as to her age and her past and future history, one may certainly say that he has given a most plausible and satisfactory explanation of the manner in which the present state of things might have come about through the operation of causes known and recognized, has opened a new field of research, and shown the way to new dominions. The introduction of the doctrine of the conservation of energy, as a means of establishing the conditions of motion and configuration in an astronomical system, is a very important step.

In the Planetary system we meet, in the main, the same problems as those that relate to the moon, with a few cases of special interest. For the most part the accordance between theory and observation in the motions of the larger planets is as close as could be expected. The labors of Leverrier, Hill, Newcomb, and others, have so nearly cleared the field that it seems likely that several decades will be needed to develop discrepancies sufficient to furnish any important corrections to our present tables. Leverrier himself, however, indicated one strik-

ing and significant exception to the general tractableness of the planets. Mercury, the nearest to the sun, and the one, therefore, which ought to be the best behaved of all, is rebellious to a certain extent; the perihelion of its orbit moves around the sun more rapidly than can be explained by the action of the other known planets. The evidence to this effect has been continually accumulating ever since Leverrier first announced the fact, some thirty years ago; and the recent investigation by Professor Newcomb, of the whole series of observed transits, puts the thing beyond question. Leverrier's own belief (in which he died) was, that the effect is due to an unknown planet or planets between Mercury and the sun; but, as things now stand, we think that any candid investigator must admit that the probability of the existence of any such body or bodies of considerable dimensions is vanishingly small. We do not forget the numerous instances of round spots seen on the solar disk, nor the eclipse-stars of Watson, Swift, Trouvelot, and others; but the demonstrated possibility of error or mistake in all these cases, and the tremendous array of negative evidence from the most trustworthy observers, with the best equipment and opportunity, make it little short of certain that there is no Vulcan in the planetary system.

A ring of meteoric matter between the planet and the sun might account for the motion of the perihelion; but, as Newcomb has suggested, such a ring would also disturb the *nodes* of Mercury's orbit. It has been surmised that the cause may be something in the distribution of matter within the solar globe, or some variation in gravitation from the exact law of the inverse square, or some supplementary electric or magnetic action of the sun, or some special effect of the solar radiation, sensible on account of the planet's proximity, or something peculiar to the region in which the planet moves; but thus far no satisfactory explanation has been established.

Mercury as yet defies all our attempts to ascertain the length of its day and the character and condition of its surface. Apparently the instruments and methods now at command are insufficient to cope with the difficulties of the problem; and it is not easy to say how it can be successfully attacked.

With Venus, the earth's twin-sister, the state of things is a little better: we do already know, with some degree of approximation, her period of rotation; and the observations of the last few months bid fair, if followed up, to determine the position of her poles, and possibly to give us some knowledge of her mountains, continents, and seas.

It would be rash to say of Mars that we have reached the limit of possible knowledge as regards a planet's surface; but the main facts are now determined, and we have a rather surprising amount of supposed knowledge regarding his geography. By "supposed" I mean merely to insinuate a modest doubt whether some of the map-makers

have not gone into a little more elaborate detail than the circumstances warrant. At any rate, while the "areographies" agree very well with each other in respect to the planet's more important features, they differ widely and irreconcilably in minor points.

Of the asteroids there is but little to be said. We are rather reluctantly obliged to admit that it is a part of our scientific duty as astronomers to continue to search for the remaining members of the group, although the family has already become embarrassingly large. Still, I think we are likely to learn as much about the constitution, genesis, and history of the solar system from these little flying rocks as from their larger relatives; and the theory of perturbations will be forced to rapid growth in dealing with the effects of Jupiter and Saturn upon their motions. Nor is it unlikely that some day the hunter for this small game may be rewarded by the discovery of some great world, as yet unknown, slow moving in the outer desolation beyond the remotest of the present planetary family. Some configurations in certain cometary orbits and some almost evanescent peculiarities in Neptune's motions have been thought to point to the existence of such a world; and there is no evidence, nor even a presumption, against it.

As regards the physical features of the asteroids we at present know practically nothing: the field is absolutely open. Whether it is worth anything may be a question; and yet, if one *could* reach it, I am persuaded that a knowledge of the substance, form, density, rotation, temperature, and other physical characteristics, of one of these little vagabonds would throw vivid light on the nature and behavior of interplanetary space, and would be of great use in establishing the physical theory of the solar system.

The planet Jupiter, lordliest of them all, still, as from the first, presents problems of the highest importance and interest. A sort of connecting link between suns and planets, it seems as if, perhaps, we might find, in the beautiful and varied phenomena he exhibits, a kind of half-way house between familiar terrestrial facts and solar mysteries. It seems quite certain that no analogies drawn from the earth and the earth's atmosphere alone will explain the strange things seen upon his disk, some of which, especially the anomalous differences observed between the rotation periods derived from the observation of markings in different latitudes, are very similar to what we find upon the sun. "The great red spot" which has just disappeared, after challenging for several years our best endeavors to understand and explain it, still, I think, remains as much a mystery as ever—a mystery probably hiding within itself the master-key to the constitution of the great orb of whose inmost nature it was an outward and most characteristic expression. The same characteristics are also probably manifested in other less conspicuous but equally curious and interesting markings on the varied and ever-changing countenance of this planet; so

that, like the Moon, it will well repay the most minute and assiduous study.

Its satellite system deserves careful observation, especially in respect to the eclipses which occur; since we find in them a measure of the time required for light to cross the orbit of the earth, and so of the solar parallax, and also because, as has been already mentioned, they furnish a test of the constancy of the earth's rotation. The photometric method of observing these eclipses, first instituted by Professor Pickering at Cambridge in 1878, and since reinvented by Cornu in Paris, has already much increased the precision of the results. With reference to the mathematical theory of the motion of these satellites, the same remarks apply as to the planetary theory. As yet nothing appears in the problem to be beyond the power and scope of existing methods, when carried out with the necessary care and prolixity; but a new and more compendious method is most desirable.

The problems of Saturn are much the same as those of Jupiter, excepting that the surface and atmospheric phenomena are less striking, and more difficult of observation. But we have, in addition, the wonderful rings, unique in the heavens, the loveliest of all telescopic objects, the type and pattern, I suppose, of world-making, in actual progress before our eyes. There seems to be continually accumulating evidence from the observations of Struve, Dawes, Henry, and others, that these whirling clouds are changing in their dimensions and in the density of their different parts; and it is certainly the duty of every one who has a good telescope, a sharp eye, and a chastened imagination, to watch them carefully, and set down exactly what he sees. It may well be that even a few decades will develop most important and instructive phenomena in this gauzy girdle of old Chronos. Great care, however, is needed in order not to mistake fancies and illusions for solid facts. Not a few anomalous appearances have been described and commented on, which failed to be recognized by more cautious observers with less vivid imaginations, more trustworthy eyes, and better telescopes.

The outer planets, Uranus and Neptune, until recently, have defied all attempts to study their surface and physical characteristics. Their own motions and those of their satellites have been well worked out; but it remains to discuss their rotation, topography, and atmospheric peculiarities. So remote are they, and so faintly illuminated, that the task seems almost hopeless; and yet, within the last year or two, some of our great telescopes have revealed faint and evanescent markings upon Uranus, which may in time lead to further knowledge of that far-off relative. Perhaps the telescope of the future will give us some such views of Neptune as we now get of Jupiter.

There is a special reason for attempts to determine the rotation periods of the planets, in the fact that there is very possibly some connection between these periods, on the one hand, and, on the other, the

planets' distances from the sun, their diameters and masses. More than thirty years ago, Professor Kirkwood supposed that he had discovered the relation in the analogy which bears his name. The materials for testing and establishing it were then, however, insufficient, and still remain so, leaving far too many of the data uncertain and arbitrary. Could such a relation be discovered, it could hardly fail to have a most important significance with respect to theories of the origin and development of the planetary system.

The great problem of the absolute dimensions of our system is, of course, commanded by the special problem of the solar parallax; and this remains a problem still. Constant errors of one kind or another, the origin of which is still obscure, seem to affect the different methods of solution. Thus, while experiments upon the velocity of light and heliometric measurements of the displacements of Mars among the stars agree remarkably in assigning a smaller parallax (and greater distance of the sun) than seems to be indicated by the observations of the late transits of Venus, and by methods founded on the lunar motions, on the other hand, the meridian observations of Mars all point to a larger parallax and smaller distance. While still disposed to put more confidence in the methods first named, I, for one, must admit that the margin of probable error seems to me to have been rather increased than diminished by the latest published results deduced from the transits. I do not feel so confident of the correctness of the value 8·80″ for the solar parallax as I did three years ago. In its very nature, this problem is one, however, that astronomers can never have done with. So fundamental is it, that the time will never come when they can properly give up the attempt to increase the precision of their determination, and to test the received value by every new method that may be found.

The problems presented by the Sun alone might themselves well occupy more than the time at our disposal this evening. Its mass, dimensions, and motions, as a whole, are, indeed, pretty well determined and understood; but when we come to questions relating to its constitution, the cause and nature of the appearances presented upon its surface, the periodicity of its spots, its temperature, and the maintenance of its heat, the extent of its atmosphere, and the nature of the corona, we find the most radical differences of opinion.

The difficulties of all solar problems are, of course, greatly enhanced by the enormous difference between solar conditions and the conditions attainable in our laboratories. We often reach, indeed, similarity sufficient to establish a bond of connection, and to afford a basis for speculation; but the dissimilarity remains so great as to render quantitative calculations unsafe, and make positive conclusions more or less insecure. We can pretty confidently infer the presence of iron and hydrogen and other elements in the sun by appearances which we can reproduce upon the earth; but we can not safely apply empirical formulæ (like that of Dulong and Petit, for instance), de-

duced from terrestrial experiments, to determine solar temperatures: such a proceeding is an unsound and unwarrantable extrapolation, likely to lead to widely erroneous conclusions.

For my own part, I feel satisfied as to the substantial correctness of the generally received theory of the sun's constitution, which regards this body as a great ball of intensely heated vapors and gases, clothed outwardly with a coat of dazzling clouds formed by the condensation of the less volatile substances into drops and crystals like rain and snow. Yet it must be acknowledged that this hypothesis is called in question by high authorities, who maintain, with Kirchhoff and Zöllner, that the visible photosphere is no mere layer of clouds, but either a solid crust, or a liquid ocean of molten metals; and there may be some who continue to hold the view of the elder Herschel (still quoted as authoritative in numerous school-books), that the central core of the sun is a solid and even habitable globe, having the outer surface of its atmosphere covered with a sheet of flame maintained by some action of the matter diffused in the space through which the system is rushing. We must admit that the question of the sun's constitution is not yet beyond debate. And not only the constitution of the sun itself, but the nature and condition of the matter composing it, is open to question. Have we to do with iron and sodium and hydrogen as we know them on the earth, or are the solar substances in some different and more elemental state?

However confident many of us may be as to the general theory of the constitution of the sun, very few, I imagine, would maintain that the full explanation of sun-spots and their behavior has yet been reached. We meet continually with phenomena which, if not really contradictory to prevalent ideas, at least do not find in them an easy explanation. So far as mere visual appearances are concerned, I think it must be conceded that the most natural conception is that of a dark chip or scale thrown up from beneath, like scum in a caldron, and floating, partly submerged, in the blazing flames of the photosphere which overhang its edges, and bridge across it, and cover it with filmy veils, until at last it settles down again and disappears. It hardly *looks* like a mere hollow filled with cooler vapor, nor is its appearance that of a cyclone seen from above. But then, on the other hand, its spectrum under high dispersion is very peculiar; not at all that of a solid, heated slag, but it is made up of countless fine dark lines, packed almost in contact, showing, however, here and there, a bright line, or at least an interspace where the rank is broken by an interval wider than that which elsewhere separates the elementary lines—a spectrum which, so far as I know, has not yet found an analogue in any laboratory experiment. It seems, however, to belong to the type of absorption spectra, and to indicate, as the accepted theory requires, that the spot is dark in consequence of *loss* of light, and not from any original defect of luminosity. Here, certainly, are problems that require solution.

The problem of the sun's peculiar rotation and equatorial acceleration appears also a most important one, and is still unsolved. Probably its solution depends in some way upon a correct understanding of the exchanges of matter going on between the interior and the surface of the fluid, cooling globe. It is a significant fact (already alluded to) that a similar relation appears to hold upon the disk of Jupiter; the bright spots near the equator of the planet completing their rotation about five minutes more quickly than the great red spot which was forty degrees from the equator. It is hardly necessary to say that an astronomer, watching our terrestrial clouds from some external station (on the Moon, for instance), would observe just the reverse. On the Earth, equatorial clouds complete their revolution *more slowly* than those in our own latitude. *Our* storms travel toward the east, while the volcanic dust from Krakatoa moved swiftly west. We may at least conjecture that the difference between different planets somehow turns upon the question whether the body whose atmospheric currents we observe is receiving more heat from without than it is throwing off itself. Whatever may be the true explanation of this peculiarity in the motion of sun-spots, it will, when reached, probably carry with it the solution of many other mysteries, and will arbitrate conclusively between rival hypotheses.

The periodicity of the sun-spots suggests a number of important and interesting problems; relating, on the one hand, to its mysterious cause, and, on the other, to the possible effects of this periodicity upon the earth and its inhabitants. I am no "sun-spottist" myself, and am very doubtful whether the terrestrial influence of sun-spots amounts to anything worth speaking of, except in the direction of magnetism. But all must concede, I think, that this is by no means yet demonstrated (it is not easy to prove a negative); and there certainly are facts and presumptions enough tending the other way to warrant more extended investigation of the subject. The investigation is embarrassed by the circumstance, pointed out by Dr. Gould, that the effects of sun-spot periodicity, if they exist at all (as he maintains they do), are likely to be quite different in different portions of the earth. The influence of changes in the amount of the solar radiation will, he says, be first and chiefly felt in alterations and deflections of the prevailing winds, thus varying the *distribution* of heat and rain upon the surface of the earth, without necessarily much changing its *absolute amount*. In some regions it may, therefore, be warmer and drier during a sun-spot maximum, while in adjoining countries it is the reverse.

There can be no question that it is now one of the most important and pressing problems of observational astronomy to devise apparatus and methods delicate enough to enable the student to follow promptly and accurately the presumable changes in the daily, even the hourly, amounts of the solar radiation. It might, perhaps, be possible even

with existing instruments, to obtain results of extreme value from observations kept up with persistence and scrupulous care for several years at the top of some rainless mountain, if such can be found; but the undertaking would be a difficult and serious affair, quite beyond any private means.

Related to this subject is the problem of the connection between the activity of the solar surface and magnetic disturbances on the earth—a connection unquestionable as matter of fact, but at present unexplained as matter of theory. It may have something to do with the remarkable prominence of iron in the list of solar materials; or the explanation may, perhaps, be found in the mechanism by means of which the radiations of light and heat traverse interplanetary space, presenting itself ultimately as a corollary of the perfected electromagnetic theory of light.

The chromosphere and prominences present several problems of interest. One of the most fruitful of them relates to the spectroscopic phenomena at the base of the chromosphere, and especially to the strange differences in the behavior of different spectrum-lines, which, according to terrestrial observations, are due to the same material. Of two lines (of iron, for instance) side by side in the spectrum, one will glow and blaze, while the other will sulk in imperturbable darkness; one will be distorted and shattered, presumably by the swift motion of the iron vapor to which it is due, while the other stands stiff and straight. Evidently there is some deep-lying cause for such differences; and as yet no satisfactory explanation appears to me to have been reached, though much ingenious speculation has been expended upon it. Mr. Lockyer's bold and fertile hypothesis, already alluded to, that at solar and stellar temperatures our elements are decomposed into others more elemental yet, seems to have failed of demonstration thus far, and rather to have lost ground of late; and yet one is almost tempted to say, "It *ought* to be true," and to add that there is more than a possibility that its essential truth will be established some time in the future.

Probably all that can be safely said at present is, that the spectrum of a metallic vapor (iron, for instance, as before) depends not only upon the chemical element concerned, but also upon its physical conditions; so that, at different levels in the solar atmosphere, the spectrum of the iron will differ greatly as regards the relative conspicuousness of different lines; and so it will happen that, whenever any mass of iron vapor is suffering disturbance, those lines only which particularly characterize the spectrum of iron in that special state will be distorted or reversed, while all their sisters will remain serene.

The problem of the solar corona is at present receiving much attention. The most recent investigations respecting it—those of Dr. Huggins and Professor Hastings—tend in directions which appear to be diametrically opposite. Dr. Huggins considers that he has suc-

ceeded in photographing the corona in full sunshine, and so in establishing its objective reality as an immense solar appendage, sub-permanent in form, and rotating with the globe to which it is attached. One may call it "an atmosphere," if the word is not to be too rigidly interpreted. I am bound to say that plates which he has obtained do really show just such appearances as would be produced by such a solar appendage, though they are very faint and ghost-like. I may add further that, from a letter from Dr. Huggins, recently received, I learn that he has been prevented from obtaining any similar plates in England this summer by the atmospheric haze, but that Dr. Woods, who has been provided with a similar apparatus, and sent to the Riffelberg in Switzerland, writes that he has an assured success.

Our American astronomer, on the other hand, at the last eclipse (in the Pacific Ocean), observed certain phenomena which seem to confirm a theory he had formulated some time ago, and to indicate that the lovely apparition is an apparition only, a purely optical effect due to the *diffraction* (not *re*fraction, nor reflection either) of light at the edge of the moon—no more a solar appendage than a rainbow or a mock-sun. There are mathematical considerations connected with the theory which may prove decisive when the paper of its ingenious and able proposer comes to be published in full. In the mean time it must be frankly conceded that the observations made by him are very awkward to explain on any other hypothesis.

Whatever may be the result, the investigation of the status and possible extent of a nebulous envelope around a sun or a star is unquestionably a problem of very great interest and importance. We shall be compelled, I believe, as in the case of comets, to recognize other forces than gravity, heat, and ordinary gaseous elasticity, as concerned in the phenomena. As regards the actual existence of an extensive gaseous envelope around the sun, it may be added that other appearances than those seen at an eclipse seem to demonstrate it beyond question—phenomena such as the original formation of clouds of incandescent hydrogen at high elevations, and the forms and motions of the loftiest prominences.

But, of all solar problems, the one which excites the deepest and most general interest is that relating to the solar heat, its maintenance and its duration. For my own part, I find no fault with the solution proposed by Helmholtz, who accounts for it mainly by the slow contraction of the solar sphere. The only objection of much force is, that it apparently limits the past duration of the solar system to a period not exceeding some twenty millions of years; and many of our geological friends protest against so scanty an allowance. The same theory would give us, perhaps, half as much time for our remaining lifetime; but this is no objection, since there is no reason to deny the final cessation of the sun's activity, and the consequent death of the system. But while this hypothesis seems fairly to meet the re-

quirements of the case, and to be a necessary consequence of the best knowledge we can obtain as to the genesis of our system and the constitution of the sun itself, it must, of course, be conceded that it does not yet admit of any observational verification. No measurements within our power can test it, so far as appears at present.

It may be admitted, too, that much can be said in favor of other theories; such as the one which attributes the solar heat to the impact of meteoric matter, and that other most interesting and ingenious theory of the late Sir William Siemens. As regards the former, however, I see no escape from the conclusion, that if it were exclusively true, the earth ought to be receiving, as was pointed out by the late Professor Peirce, as much heat from meteors as from the sun. This would require the fall of a quantity of meteoric matter—more than sixty million times as much as the best estimates make our present supply, and such as could not escape the most casual observation, since it would amount to more than a hundred and fifty * tons a day on every square mile.

As regards the theory of Siemens, the matter has been, of late, so thoroughly discussed that we probably need spend no time upon it here. To say nothing as to the difficulties connected with the establishment of such a far-reaching vortex as it demands, nor of the fact that the temperature of the sun's surface appears to be above that of the dissociation-point of carbon compounds, and hence above the highest heat of their combustion, it seems certainly demonstrated that matter of the necessary density could not exist in interplanetary space without seriously affecting the planetary motions by its gravitating action as well as by its direct resistance; nor could the stellar radiations reach us, as they do, through a medium capable of taking up and utilizing the rays of the sun in the way this theory supposes.

And yet I imagine that there is a very general sympathy with the feeling that led to the proposal of the theory—an uncomfortable dissatisfaction with received theories, because they admit that the greater part of the sun's radiant energy is, speaking from a scientific point of view, simply wasted. Nothing like a millionth part of the sky, as seen from the sun, is occupied, so far as we can make out, by objects upon which its rays can fall: the rest is vacancy. If the sun sends out rays in all directions alike, not one of them in a million finds a target, or accomplishes any useful work, unless there is in space some medium to

* In an article on astronomical collisions, published in the "North American Review" about a year ago, I wrongly stated the amount at fifty tons. There was some fatality connected with my calculations for that article. I gave the amount of heat due to the five hundred tons of meteoric matter, which is supposed to fall daily on the earth with an average velocity of fifteen miles per second, as fifty-three calories annually per square metre—a quantity two thousand times too great. Probably the error would have been noticed if even the number given had not been so small, compared with the solar heat, as fully to justify my argument, which is only strengthened by the correction. I owe the correction to Professor Le Conte, of California, who called my attention to the errors.

utilize the rays, or unknown worlds of which we have no cognizance, beyond the stars.

Now, for my own part, I am very little troubled by accusations of wastefulness against Nature, or by demands for theories which will show what the human mind can recognize as "use" for all energy expended. Where I can perceive such use, I recognize it with reverence and gratitude, I hope; but the failure to recognize it in other cases creates in my mind no presumption against the wisdom of Nature, or against the correctness of an hypothesis otherwise satisfactory. It merely suggests human limitations and ignorance. How can one without sight understand what a telescope is good for?

At the same time perhaps we assume with a little too much confidence that, in free space, radiation does take place equally in all directions. Of course, if the received views as to the nature and conduct of the hypothetical "ether" are correct, there is no possibility of questioning the assumption; but, as Sir John Herschel and others have pointed out, the properties which must be ascribed to this "ether," to fit it for its various functions, are so surprising and almost inconceivable that one may be pardoned for some reserve in accepting it as a finality. At any rate, as a fact, the question is continually started (the idea has been brought out repeatedly, in some cases by men of recognized scientific and philosophic attainment), whether the constitution of things may not be such that radiation and transfer of energy can take place only between ponderable masses; and that, too, without the expenditure of energy upon the transmitting agent (if such exist) along the line of transmission, even *in transitu*. If this were the case, then the sun would send out its energy only to planets and meteors and sister-stars, wasting none in empty space; and so its loss of heat would be enormously diminished, and the time-scale of the life of the planetary system would be correspondingly extended. So far as I know, no one has ever yet been able to indicate any kind of medium or mechanism by which vibrations, such as we know to constitute the radiant energy of light and heat, can be transmitted at all from sun to planet under such restrictions; and it is very difficult to see how any such limited transmission, confined to the lines of gravitational force, could be reconciled with the law of inverse squares. That this law of radiation actually holds in interplanetary space is of course demonstrated by the fact that the calculated brightness of a planet at different places in its orbit and varying distances from the earth agrees with the results of photometric observation. Still, one ought not to be too positive in assertions as to the real condition and occupancy of so-called vacant space. The "ether" is a good working hypothesis, but hardly more as yet.

I need not add that a most interesting and as yet inaccessible problem, connected with the preceding, is that of the mechanism of gravitation, and, indeed, of all forces that seem to act at a distance:

as for that matter, in the last analysis, *all* forces do. If there really be an "ether," then it would seem that somehow all attractions and repulsions of ponderable matter must be due to its action. Challis's investigations and conclusions as to the effect of hydrodynamic actions in such a medium do not seem to have commanded general acceptance; and the field still lies open for one who will show how gravitation and other forces can be correlated with each other through the ether.

Meteors and the comets, seeming to belong neither to the solar system nor to the stellar universe, present a crowd of problems as difficult as they are interesting. Much has undoubtedly been gained during the last few decades, but in some respects that which has been learned has only deepened the mystery. The problem of the origin of comets has been supposed to be solved to a certain extent by the researches of Schiaparelli, Heis, Professor Newton, and others, who consider them to be strangers coming in from outer space, sometimes "captured" by planets, and forced into elliptic orbits, so as to become periodic in their motion. Certainly this theory has strong supports and great authority, and probably it meets the conditions better than any other yet proposed. But the objections are really great, if not insuperable—the fact that we have so few, if any, comets moving in hyperbolic orbits, as comets *met* by the sun would be expected to move; that there seems to be so little relation between the direction of the major axes of cometary orbits and the direction of the solar motion in space; and especially the fact, pointed out and insisted upon by Mr. Proctor in a recent article, that the alteration of a comet's natural parabolic orbit to the observed elliptic one, by planetary action, implies a reduction of the comet's velocity greater than can be reasonably explained. If, for instance, Brorsen's comet (which has a mean distance from the sun a little more than three times that of the earth) was really once a parabolic comet, and was diverted into its present path by the attraction of Jupiter, as generally admitted, it must have had its velocity reduced from about eleven miles a second to five. Now, it is very difficult, if not out of the question, to imagine any possible configuration of the two bodies and their orbits which could result in so great a change. While I am by no means prepared to indorse as conclusive all the reasoning in the article referred to, and should be very far from ready to accept the author's alternative theory (that the periodic comets have been ejected from the planets, and so are not their captives, but their children), I still feel that the difficulty urged against the received theory is very real, and not to be evaded, though it may possibly be overcome by future research.

Still more problematical is the constitution of these strange objects of such enormous volume and inconceivable tenuity, self-luminous and transparent, yet reflecting light, the seat of forces and phenomena unparalleled in all our other experience. Hardly a topic relating to their appearance and behavior can be named which does not contain

an unsolved problem. The varying intensity, polarization, and spectroscopic character of their light; the configurations of the nucleus and its surrounding nebulosity; and especially the phenomena of jets, envelopes, and tail—all demand careful observation and thorough discussion. I think it may be regarded as certain that the explanation of these phenomena when finally reached, if that time ever comes, will carry with it, and be based upon, an enormous increase in our knowledge as to the condition, contents, and temperature of interplanetary space, and the behavior of matter when reduced to lowest terms of density and temperature.

Time forbids any adequate discussion of the numerous problems of stellar astronomy. One work, in its very nature incessant and interminable, consists, of course, in the continual observation and cataloguing of the places of the stars, with ever-increasing precision. These star-places form the scaffold and framework of all other astronomical investigations involving the motions of the heavenly bodies: they are the reference-points and bench-marks of the universe. Ultimately, too, the comparison of catalogues of different dates will reveal the paths and motions of all the members of the starry host, and bring out the great orbit of the sun and his attendant planets. Meanwhile, micrometric observations are in order, upon the individual stars in different clusters, to ascertain the motions which occur in such a case; and the mathematician is called upon again to solve the problem of such movement.

Now, too, since the recent work of Gill and Elkin in South Africa, and of Struve, Hall, and others elsewhere, upon stellar parallax, new hopes arise that we may soon come to some wider knowledge of the subject; that, instead of a dozen or so parallaxes of doubtful precision, we may get a hundred or more relating to stars of widely different brightness and motion, and so be enabled to reach some trustworthy generalizations as to the constitution and dimensions of the stellar universe, and the actual rates of stellar and solar motion in space.

Most interesting, also, are the studies now so vigorously prosecuted by Professor Pickering in this country, and many others elsewhere, upon the brightness of the stars, and the continual variations in this brightness. Since 1875 stellar photometry has become almost a new science.

Then there are more than a myriad of double and multiple stars to watch, and their orbits to be determined; and the nebulæ claim keen attention, since some of them appear to be changing in form and brightness, and are likely to reveal to us some wonderful secrets in the embryology of worlds. Each star also presents a subject for spectroscopic study; for although, for the most part, the stars may be grouped into a very few classes from the spectroscopic point of view, yet, in detail, the spectra of objects belonging to the same group differ considerably and significantly, almost as much as human faces do.

For such investigations new instruments are needed, of unexampled powers and accuracy, some for angular measurements, some for mere power of seeing. Photography comes continually more and more to the front; and the idea sometimes suggests itself that by-and-by the human eye will hardly be trusted any longer for observations of precision, but will be superseded by an honest, unprejudiced, and unimaginative plate and camera. The time is not yet, however, most certainly. Indeed, it can never come at all, as relates to certain observations; since the human eye and mind together integrate, so to speak, the impressions of many separate and selected moments into one general view, while the camera can only give a brutal copy of an unselected state of things, with all its atmospheric and other imperfections.

New methods are also needed, I think (they are unquestionably possible), for freeing time-observations from the errors of personal equation; and increased precision is demanded, and is being progressively attained, in the prevention, or elimination, of instrumental errors, due to differences of temperature, to mechanical strains, and to inaccuracies of construction. Astronomers are now coming to the investigation of quantities so minute that they would be completely masked by errors of observation that formerly were usual and tolerable. The science has reached a stage where, as was indicated at the beginning of this address, it has to confront and deal with the possible unsteadiness of the earth's rotation, and the instability of its axis. The astronomer has now to reverse the old maxim of the courts: for him, and most emphatically at present, *de minimis curat lex.* Residuals and minute discrepancies are the seeds of future knowledge, and the very foundations of new laws.

And now, in closing this hurried and inadequate, but I fear rather tedious, review of the chief problems that are at present occupying the astronomer, what answer can we give to him who insists, *Cui bono?* and requires a reason for the enthusiasm that makes the votaries of our science so ardent and tireless in its pursuit? Evidently very few of the questions which have been presented have much to do directly with the material welfare of the human race. It may possibly turn out, perhaps, that the investigation of the solar radiation, and the behavior of sun-spots, may lead to some better understanding of terrestrial meteorology, and so aid agricultural operations and navigation. I do not say it will be so—in fact, I hardly expect it—but I am not sure it will not. Possibly, too, some few other astronomical investigations may facilitate the determination of latitudes and longitudes, and so help exploration and commerce; but, with a few exceptions, it must be admitted that modern astronomical investigations have not the slightest immediate commercial value.

Now, I am not one of those who despise a scientific truth or principle because it admits of an available application to the affairs of what

is called "practical life," and so is worth something to the community in dollars and cents: its commercial value is—just what it is—to be accepted gratefully. Indirectly, however, almost all scientific truth has real commercial value, because "knowledge is power," and because (I quote it not irreverently) "the truth shall make you free"—any truth, and to some extent; that is to say, the intelligent and intellectually cultivated will generally obtain a more comfortable livelihood, and do it more easily, than the stupid and the ignorant. Intelligence and brains are most powerful allies of strength and hands in the struggle for existence; and so, on purely economical grounds, all kinds of science are worthy of cultivation.

But I should be ashamed to rest on this lower ground: the highest value of scientific truth is not economic, but different and more noble; and, to a certain and great degree, its truest worth is more as an object of pursuit than of possession. The "practical life"—the eating and the drinking, the clothing and the sheltering—comes *first*, of course, and is the necessary foundation of anything higher; but it is not the whole or the most or the best of life. Apart from all spiritual and religious considerations, which lie one side of our relations in this Association, there can be no need, before this audience, to plead the higher rank of the intellectual, æsthetic, and moral life above the material, or to argue that the pabulum of the mind is worth as much as food for the body. Now, I safely assert that, in the investigation and discovery of the secrets and mysteries of the heavens, the human intellect finds most invigorating exercise, and most nourishing and growth-making aliment. No other scientific facts and conceptions are more effective in producing a modest, sober, truthful, and ennobling estimate of man's just place in nature, both of his puny insignificance, regarded as a physical object, and his towering spirit, in some sense comprehending the universe itself, and so akin to the divine. A nation or an individual oppressed by poverty, and near to starving, needs first, most certainly, the trades and occupations which will provide food and clothing. When bodily comfort has been achieved, then higher needs and wants appear; and then science, for truth's own sake, comes to be loved and honored along with poetry and art, leading into a larger, higher, and nobler life.

DROWNING THE TORRENT IN VEGETATION.

By S. W. POWELL.

THE extraordinarily disastrous floods of 1883–'84, in the Ohio River, have again called public attention to the close relation which the wooded or unwooded condition of steep hill-sides, in the areas drained by streams, bears to the volume of water flowing in them.

The State of New York, in particular, is discussing the question of making a great forest reservation in the Adirondacks, in order to avert floods, droughts, and other calamities which there is reason to fear may follow the alleged rapid destruction of the forests of that region.

In the course of this discussion many allusions have been made to the ravages of floods in the south of France, and to the success of efforts to tame those torrents, by reforesting the basins which they drained. A short account of those torrents and their origin, the ruin wrought by them, and the victory which forest science has gained over them, may interest the readers of "The Popular Science Monthly."

Professor Guyot, whose recent death is such a great loss to science, taught that variety of coast-outline, of elevation, of climate, and natural products, is necessary for the richest development of the individual and of society; and that in no part of the world were so many of these favoring conditions originally brought together as in the regions bordering the Mediterranean.

The Roman Empire, which, at the time when it was most widely extended, consisted almost entirely of the countries lying around or near this sea, had the best situation of any of the great empires that have arisen. The grouping and arrangement of the land and water masses; the diversity of elevation and of coast-outline; the rich and varied scenery; the wide range of animal, vegetable, and mineral products; the great number of populous, wealthy, and nobly built cities, with the marvelous Roman roads binding them together, and the majestic Roman law co-ordinating their civic life—all co-operated to make this region the garden of the world. The fact that the most favored part of the earth's surface should have been so nearly ruined, as it has been, by selfish and short-sighted treatment of the forest, its most precious possession, ought to have been a lesson to all future settlers of new territory. That it has not been heeded by the settlers of North America, the increasing frequency and severity of floods and droughts and the swift and menacing approach of timber-famine plainly prove.

The streams which flow through the valleys that wind back from the sea into the heart of the mountains and hills bordering the Mediterranean would, in their normal condition, be limpid and perennial. But, owing to this short-sighted cutting of timber from steep hillsides, and to the equally short-sighted over-pasturing of the cleared spaces afterward with sheep and goats, most of these streams were, in the upper part of their courses, changed into torrents, whose beds in dry weather are cheerless expanses of sand and gravel.

During heavy rain, or when snow is rapidly melted upon the mountains (and this is especially apt to occur when a warm wind, called the *Fœhn*, coming probably from Sahara, and saturating itself with

moisture as it crosses the Mediterranean, strikes the mountains—Guyot said he had known this wind to melt six feet of snow in twenty-four hours), these torrent-channels are almost instantly filled with furious, short-lived floods, which often sweep off bridges, buildings, crops, and even animals and human beings, besides tearing up costly roads, and wash away a vast amount of precious soil from mountain-sides, where it is sorely needed, and deposit it in rivers and harbors, where it is a nuisance, and often a serious peril to navigation.

In their gullying and undermining rage, these torrents tear out stones and large rocks from the hill-sides, grind them up into gravel, and even fine sand, and ruin much fertile land upon which they spread this material.

Marsh, in his "Earth as modified by Human Action" (p. 272), gives Surell* as his authority for the statement that "the fury of the waters, and of the wind which accompanies them in the floods of the French Alpine torrents, is such that large blocks of stone are hurled out of the bed of the stream to the height of twelve or thirteen feet"; and remarks that "the impulse of masses driven with such force overthrows the most solid masonry, and their concussion can not fail to be accompanied by the crushing of the rocks themselves." On page 273, note, he quotes Coaz ("Die Hochwasser im 1868," p. 54): "At Rinkenberg, on the right bank of the Vorder Rhein, in the flood of 1868, a block of stone, computed to weigh nearly nine thousand cwt., was carried bodily forwards, not rolled, by a torrent, a distance of three quarters of a mile."

But there is further mischief, which, as being more widely diffused, is less sure to be assigned to the true cause—the stripping steep land of its covering of trees:

1. There is the failure of springs, because water of precipitation, which should have been delayed upon the hill-sides by the roots, sprouts, mosses, fallen leaves, etc., which fill and cover the surface of the ground under a forest, till it could find the underground spring-sources, runs off the bare slopes in a few hours. Dry springs mean parched pastures, small crops, and unprofitable husbandry.

2. The increased cost of buildings, bridges, furniture, and implements of all sorts, which are, in whole or in part, made of wood. A large item in the current expenses of railroads is the outlay for ties, which must be renewed frequently. Wood for fuel or structural uses is a prime necessity of civilized life; and, as it is bulky, its cost increases rapidly with the distance it must be carried to reach the consumer. Many countries have no stores of coal or peat, and must have wood, or be sorely stinted for fuel; that stinting is a waste of time, health, and vitality. Floods make the maintenance of roads difficult and costly, and so, of course, increase the expense of whatever

* "*Étude sur les Torrents des Hautes Alpes*," published in 1841. This and the supplementary volume by Cézanne (1870) are of the first importance.

must be hauled over them, especially anything so bulky as wood.* Further, scarcity of timber means the cessation of many lucrative industries which use wood for their raw material, and which are especially desirable as affording employment during portions of the year, when agriculture or the care of flocks does not call for all of the farmer's time.

3. There is the derangement of climate and rainfall. It is by no means certain that, at least, in some situations, more rain will not fall in a year upon a well-wooded than upon a bare region. Certainly, what does fall will not evaporate, and be carried away by the winds as quickly. Sudden changes of temperature, and the resulting violent winds are also less liable to occur where woods abound. A forest is a better barrier against wind than a stone wall of equal height, because it divides its force, and does not stop it all at once, causing eddies and rebounds which may do damage elsewhere.

In these and other ways many provinces of Southern France had been (before 1860) for several generations gradually growing poorer. By a misuse of the right of equal common pasturage upon the lands belonging to the communes, the richer proprietors who had large flocks could get the lion's share of the scanty store. To lighten taxes, sheep and goats were admitted from Provence and the Maritime Alps to summer pasturage, as at that season their own country was so dry and parched that they could find no food. Cézanne, in his supplement to the great work of Surell on the "Torrents of the High Alps," says these migratory flocks "obstruct the roads, and are the occasion of all kinds of disorder. They arrive at the pastures famished, and in a few days destroy the sprouting herb, the hope of the entire season. . . . One can follow the trail of the sheep of Provence by the disappearance of all vegetation. They necessarily migrate in flocks of one thousand or twelve hundred, and after reaching the pastures retain the habit—which they acquire upon the road—of crowding together and struggling for every spear of grass. In the flinty plains of the south they find very scanty fare, and, to satisfy hunger, are obliged to move stones with their noses and feet, and to dig the soil quite down to the roots of the plants which they devour. Upon the mountains they continue the same destructive habits, and one can understand what must be the effect upon the light soil, scarcely fixed upon the slopes, of such digging and tearing by these millions of animals" (pp. 245, 246).

The little ready money which the pasture-fee of these southern

* Ladoucette, in his "Histoire, Topographie, Antiquités, Usages, Dialectes des Hautes Alpes," says that the peasant of Dévoluy often goes a distance of five hours, over rocks and precipices, for a single man's load of wood; and that the justice of the peace for that cantonment had, in the course of forty-three years, but once heard the voice of the nightingale. Thanks to reforesting, wood and nightingales' songs are there now in abundance.

sheep brought into the impoverished communal treasuries seemed indispensable, though it was easy to see that it was bad economy to admit them. Such trampling and tearing weakened the turf so that it was every year more easily washed down-hill during heavy rain, and, when it went, the soil underneath went too. The farther down the mud and water rushed, the deeper and wider were the erosions. Upon the steeper slopes below, which should have been clothed with woods, the ravages were still greater. As like causes were operating in a similar way upon other surfaces in the same basin, after every heavy rain (especially if it fell upon deep snow) the streams suddenly rose thirty, forty, and even sixty feet, and then again, in a few hours, were at their old level.

If a bank overhanging the narrow gorge at the mouth of one of these mountain-basins was undermined and fell across the opening, a lake quickly formed behind, until the accumulating pressure burst the barrier, and then woe to the people down-stream! In one such *débâcle* the wave was one hundred feet high, and swept down the valley at the rate of fifty feet a second, or thirty-four and one eleventh miles an hour! "At one point the water was seen pushing before it a moving mountain of all kinds of *débris* of three hundred feet in height, from which was rising a thick cloud like the smoke of a conflagration" (Brown's "Reboisement in France," pp. 86–89).

Deprived by their own improvidence, or that of their parents, of their forest wealth, the mountaineers thought that they must starve, or else use every available acre for pasturage. Planting trees and waiting for them to grow required knowledge and capital, and they had little of either. The damage done by torrents was more severe farther down, although it all began in the uplands, whose turf was loosened by the starved sheep of the south. Lack of the timber which should have enriched and protected the zones just below these pastures made the mountaineers feel so poor that they felt constrained to take every sheep and goat which the lowlanders would bring. It was clear that they could not restrict the number of these "summer boarders" and at the same time reforest the steeper lower zones to the extent which was demanded by their own welfare, and still more by that of the people living farther down-stream.

This made it necessary for the state to step in. Under the feudal system it was held that a seignior, and especially a king, must possess one or more forests. In France, those belonging to the crown have become the property of the state, and, for the care of these there have gradually been trained a special class of officers. When the reboisement law of 1860 was passed, many of these were men of great attainments. Surell, born in the Département des Hautes-Alpes, was one of the most eminent among them. As an engineer he had long been familiar with the numerous and costly—and yet inadequate—mechanical expedients which had been tried by the authorities for the purpose of

preventing the ravages of torrents. He kept dinning it into their ears that, since excessive and unscientific clearings, and unregulated pasturage of the cleared spaces afterward, were the causes of the torrents, so the remedy must be to clothe the steeper zones below the pastures with trees or bushes, and to exclude sheep and goats from the pastures above until they were again covered with a stable turf.

He was not, indeed, the first to protest against the destruction of the woods, and to insist upon their restoration. The famous inventor, engineer, and artist, Bernard Palissy (born about 1509), had discovered the influence of forests upon springs, and raised an unheeded cry to warn men against the calamities which lack of fuel and timber would occasion. The chief nobles, and especially the ecclesiastics, were clearing at a great rate and taking no thought of those who would come after them. In the time of Henry IV and Louis XIV a sharp check was given to the plundering of the crown forests by these ecclesiastics and court favorites. In 1669, three years after the famous announcement of Louis XIV that he had been long enough in leading-strings, and that he proposed from that time to be master of himself and of France, the great ordinance was passed upon which most of the subsequent forest legislation of Europe has been based. Under it, in connection with the crown forests, the science of arboriculture was studied, and a thoroughly organized corps of officials trained.

Before we come to Surell, a passing mention should be made of Fabre and Dugied. Fabre published in 1797 his "Essai sur la Théorie des Torrents et des Rivières," which may be called a prophetic work. It outlines quite distinctly the main principles which were followed in the works of restoration under the reboisement law of 1860. He said sheep and goats must be kept away from young trees, and that no clearing should be permitted except in horizontal strips not more than thirty feet in width where the acclivity of a slope is more than one foot in three, and these strips may be made wider according as the slopes are less steep. No clearings without authorization of competent officials, and on plans made by them. Where there was little earth left, he recommended *gazonnement** and *buissement*.

Dugied, who had been a prefect in the Lower Alps, published a project for reforesting the Basses-Alpes. He said that more than half that department was dry and unproductive soil, and that torrents caused by cutting and grubbing woodland brought *débris* and added to the barren areas. For remedies he recommended: 1. Enforcement of the old law of 1667, which imposed a fine of three thousand francs for grubbing steep land; land already grubbed to be turned into

* *Reboiser*, to reforest; *deboiser*, to deforest; *gazonner*, to plant with turf; *buissonner*, to plant with bushes, with their nouns, *boisement*, *reboisement*, *deboisement*, *gazonnement*, *buissonnement*, are in constant use in French forest literature. The nouns are, in translations, often transferred to the English, and sometimes one meets, to *reboise* = to *reforest*.

artificial meadows. 2. He made careful estimates of the cost of reforesting the one hundred and fifty thousand hectares in the department which needed it, and recommended that, besides remitting taxes for ten years on reforested land, and distributing seeds gratis, the state should pay three quarters and the department one quarter of the cost. He showed that the increased revenue from taxes, after the ten years of exemption, would repay the advance in eighty-six years.

Almost every one ridiculed the proposal; it was compared to the "Arabian Nights"; and, as a reward for making it, he was deposed. But, at the same time the state was expending one hundred and twenty million francs each year for roads and bridges, and a large part of this outlay—vastly more than reforesting cost when at last wiser counsels prevailed—was made necessary by torrents which every year grew worse, but which reforesting cured.

Dugied's ideas were, in the main, those finally adopted, except that he left out the essential idea of compulsion. An entire torrent-basin must be taken in hand at the same time, and one uniform process be carried on over the whole of it. As Surell said, success should not be imperiled by the first stupid or stubborn peasant who would not do his part. The state must not only bear the expense, but also assume the direction. Expropriation or confiscation must be resorted to, as is done in taking land for roads, etc.

In May, 1856, when heavy rains fell all over France, floods in the valleys of the Loire and the Rhone did incalculable damage. This so re-enforced the appeals which had been made by specialists like Fabre, Dugied, and Surell, that the Corps Législatif consented to make a trial of the new way of fighting floods. The old way—erecting barriers, etc.—had been altogether defensive; the new was almost wholly offensive. The method, as an expert expressed it, was "*to drown the torrent in vegetation*"—that is, to turf the higher and more level pastures, and then to retard the flow of water down the steeper slopes below the pastures by trees, bushes, fallen leaves, and mosses, so that much of it would have time to soak into the ground and reach the spring-reservoirs, and another large portion be absorbed by the fallen leaves, etc., and held as by a sponge, or be taken up by the growing vegetation; and to hold back the remainder by millions of small obstacles so that it would reach the stream no faster than a full channel could carry it away; and, finally, that, flowing at no point over bare soil, it might reach the stream-bed as limpid as when it started down-hill.

Difficulties.—The hindrances to the success of the work were both moral and physical, but the moral were the greater. They were: 1. The unwillingness of an ignorant peasantry to try any new thing; 2. Reluctance on the part of the Corps Législatif and of local authorities to interfere with private rights as much as the success of the work

demanded; and, 3. The doubt whether such torrents would not wash away the plantations as fast as they could be made.

The first two difficulties demanded great patience and kindness in making clear to the peasants the necessities and advantages of reforesting, and in convincing them that the work would be done so honestly and cheaply that they might reasonably expect to be able to repay the cost of the work and get back their land, which would soon begin to yield some income, and in the course of twenty years would, as a rule, be more profitable than pasture-land. A sort of science primer, "Les Études de Maître Pierre sur l'Agriculture et les Forêts," was prepared and circulated among them with excellent results. It consists of eight dialogues between a government teacher and a peasant, Maître Pierre, in which the latter is converted from a stubborn opposition to the reboisement law (which he said would ruin him because, in obedience to it, his landlord was about to withdraw a certain pasture from his *moutons*) to a quite intelligent advocacy of it. The main reasons for and methods of forest propagation, conservation, cutting, thinning, etc., are gradually instilled into the peasant's not very bright mind. The book is a fine model of Socratic teaching.

The velvet glove was always kept upon the iron hand in carrying out the law. As far as possible the co-operation of those whose land was taken was secured; and none was taken except after full opportunity for every one to learn just what the government meant to do and to present objections. Local magistrates and land-owners must be united with the state officials upon the boards which decided where to run the lines which included lands to be reforested.

The third difficulty—doubt as to the possibility of success—was overcome by the prudently bold policy of attacking some of the worst torrents first. Of course, victory over these insured success with less violent ones.

The conflicts with physical obstacles may be classified as preparatory and final. The first thing was to exclude sheep and goats from the pastures above the forest zone. The next was to divide the whole area by horizontal walls into two or more zones, and in the lateral ravines to build as many dams as the case might require, so as to check the downward flow of water and compel deposit of earth above the walls and dams. In the deeper ravines whole trees were thrown with tops down-hill, fascines, etc., being packed among the limbs. Then, with explosives, the sides of the ravines were thrown down upon these trees so as to afford a deep and somewhat level soil that could be planted at once. Horizontal mule-paths about a metre wide were made where, later on, roads for working the forest would be needed. These paths, in passing ravines, ran upon the dams, etc., and by them laborer and material could reach the points where they were needed in the preliminary works. Besides these paths there were made, at distances twelve

or fourteen feet apart, narrow terraces, supported on their lower edges by pebble walls, and having their upper surfaces slightly sloping in toward the mountain, so that water would be checked, and, as far as possible, made to soak in and find the spring-reservoirs.

After all these preliminary works were executed, the final planting began. Generally, the terraces and the more level and deep made-ground in the lateral ravines were stocked from nurseries which were established here and there in the districts to be reclaimed. Where the spaces between the terraces were especially liable to washing, they were covered by thatchings of brush, retained if necessary by stones or any convenient rubbish.

In gorges and other places where the danger of erosion and the difficulty of getting out large timber would be greater than elsewhere, the kinds of trees selected were such as shoot readily from the stump, grow rapidly, and can be frequently cut with profit—in other words, those more especially suited to coppice or sprout-growth culture. A dense coppice resists the pelting of rain and fixes the soil better than larger trees. The kinds selected for such places were therefore acacias, ashes, elms, maples, willows, alders, poplars, lindens, etc.

By working with a sufficiently large force to cover an entire basin with the various preliminary works, and then to plant, promptly and simultaneously, the plantations were not washed away; on the contrary, to use the vivid words of Cézanne: "These works, so ingenious in their very simplicity, form a net-work of horizontal lines, like the alleys of a garden. The green edgings and linings develop themselves among the innumerable sinuosities of the *combes* [valleys], embracing, from the rocky beds of the torrents to the very summit of the mountain-crests, those ravines which were but lately inaccessible, and presented an aspect full of horror. On seeing what has been done, one immediately understands how such a combination should be effectual. Every liquid molecule, so to speak, is seized individually, the thin sheet of water flowing down is retarded in its course by a thousand thirsty little plants, by the lines of cultivated herbage, and by the hedges of shoots and trees. It is compelled to tarry a little on each terrace to slake the thirst of the ground, and when it reaches the lower end of a furrow it spreads itself out on the flattened bed there prepared for it. Stopped at every barrier, it loses its vital force on every hand, and finally, from resting-place to resting-place, and from descent to descent, it arrives, after a thousand retardations, and still limpid, in the channel which conveys it to the river. The violence of torrents is occasioned by the combination of an infinitude of elements infinitely minute; and the system of extinction consists in extinguishing each of these elements without disregarding one; it is an accumulation of infinitesimal littles. The secondary ravines are blocked up, their minute ramifications are intercepted, the lesser flanks are filled up, and finally there are spread over the soils, completely to diffuse them,

the innumerable threadlets [of water], divided and subdivided like the fibers of a root."

In conclusion, it is gratifying to be able to state that all opposition to the reboisement law is in France a thing of the past. The credits voted for the first ten years were at the rate of only two hundred thousand francs a year. Now nearly twenty times as much is readily obtained by the forest administration. The total annual outlay upon the state forests is about twelve million francs, but the direct revenue derived from them is more than three times that sum, besides the vastly greater incidental advantage of building up the agriculture, commerce, manufactures, health, and general prosperity of the restored regions, to say nothing of the diminished expenditure needed to replace roads, bridges, and other structures formerly destroyed by the torrents. How much longer shall we refuse to heed what the experience of other countries teaches with regard to the treatment of forests?

In the recent Ohio floods the States which suffered most—Ohio, Indiana, and Illinois—were not those where most of the deforesting was done which caused the floods. The Hudson's head-waters are almost all in New York, and it is in the power of her Legislature to provide the needed safeguards.

WHAT IS ELECTRICITY?*

By JOHN TROWBRIDGE,
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THE conjunction of the meeting of the American Association with the opening of the Electrical Exposition and the sittings of the National Electrical Congress leads me to say a few words upon a question which we all ask ourselves, and to which we have hitherto had no response: "What is electricity?"

After I have concluded, you will probably still ask yourselves, "What is electricity?" All I can hope to do is to make you ask yourselves the question with more humility, and a greater consciousness of ignorance; for the ignorant man, I have found, is generally sure that he knows what electricity is; and, the more learned a person is, the more he is convinced that he does not know what electricity is.

There is an advantage in sounding the depths of our ignorance, and in surveying, even from a small Mount Pisgah, the paths we have traversed, and the great promised land which lies before us. In the beginning I must express my conviction that we shall never know

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what electricity is, any more than we shall know what energy is. What we shall be able probably to discover is, the relationship between electricity, magnetism, light, heat, gravitation, and the attracting force which manifests itself in chemical changes. We have one great guiding principle which, like the pillar of cloud by day, and the pillar of fire by night, will conduct us, as Moses and the Israelites were once conducted, to an eminence from which we can survey the promised scientific future. That principle is the conservation of energy. To-day we see clearly that there are not different kinds of forces; that light is not one thing and heat another; that, in truth, we should blot the word light from our physical text-books; that electricity and magnetism have their equivalents in heat, and heat in mechanical work. The ancients had a god for every great manifestation of Nature—a god of peace, a god of war, a god of the land, a god of the sea. Fifty years ago scientific men were like the ancients. There was a force attached to every phenomenon of Nature. Thus, there were the forces of electricity and magnetism, the vital forces, and the chemical forces. Now we accept treatises on mechanics which have the one word "Dynamik" for a title; and we look for a treatise on physics, which shall be entitled "Mechanical Philosophy," in which all the phenomena of radiant energy, together with the phenomena of energy, which we entitle electricity and magnetism, shall be discussed from the point of view of mechanics. It is true that Mascart and Joubert have entitled their treatise on electricity and magnetism "The Mechanical Theory of Electricity and Magnetism"; but what we are to have in the future is a treatise which will show the mechanical relations of gravitation, of so-called chemical attracting force and electrical attracting force, and the manifestations of what we call radiant energy.

When we survey the field of modern physics, we see that there is a marked tendency to simplify our conceptions. The question is sometimes asked, How shall the man of the future be able to make any advance, since it now takes one until middle age to gain familiarity with the vortex theories, with quaternions, and the more or less complicated mathematical analysis which characterizes our mechanical theory of electricity to-day? It is evident that much of our complicated scaffolding is to be taken down, and the student of electricity in the future will start with, perhaps, the laws of vortices as axioms, just as the student in physics to-day starts with the truth that the energy which we receive from the sun does not exist either as light or heat in the space between us and the sun, but may be electro-magnetic, or even in an unsuspected form; and that light and heat are merely manifestations of waves of energy differing only in length.

We have reduced our knowledge of electricity and magnetism to what may be called a mechanical system, so that, in a large number

of cases, we can calculate beforehand what will take place, and we are under no necessity of trying actual experiments.

Thus, a portion of our knowledge of electro-magnetism is very much in the condition of our knowledge of what may be called geometrical astronomy, in distinction to physical astronomy. We can calculate what will take place with small errors, which arise merely from the faults of observation, and not from a want of knowledge of conditions, or from the errors of a defective theory. It is probable, for instance, that the correct form of a dynamo-machine for producing the electric light can be calculated, and the plans drawn with as much certainty as the diagrams of a steam-engine are constructed. There is a department of electricity corresponding, perhaps, to hydraulics, in which the electrical engineer can find full employment in subjecting perfectly definite conditions to exact calculation. We can congratulate ourselves, therefore, in having a large amount of systematic knowledge in electricity, and we see clearly how to increase this systematic knowledge; for we have discovered that a man, to become an electrician, can not expect to master the subject of electricity, who has not made himself familiar with thermo-dynamics, with analytical mechanics, and with all the topics now embraced under the comprehensive title of physics.

Some may think that an electrician is a narrow specialist. I can only invite such persons to engage in the study of "What is electricity?"

In standing upon our scientific Mount Pisgah, we can survey the beaten roads by which we have advanced, and can see partially what has been good and what has been bad in the theories which have stood in the place of the leaders of the Israelites and have conducted us thus far. Out of all the theories—the two-fluid theory, the one-fluid, or Franklin theory, and the various molecular theories—not one remains to-day under the guidance of which we are ready to march onward. The two-fluid theory serves merely to fix the ideas of the student whose mind is new to the subject of electricity. I think I can safely affirm that no scientific man of the present believes that there is even one electric fluid, to say nothing of the existence of two. We have discovered that we can not speak of the velocity of electricity. We do not know whether the rate of propagation of what we call an electrical impulse is infinitely slow or infinitely fast. We do not know whether what we call the electrical current in a conductor is due to molecular motions infinitely faster than those of outlying molecules, or whether there is a sudden comparative cessation of molecular motion in the wire through which the current manifests itself, compared with the molecular motions outside the wire, for this might produce the electrical phenomena we observe. We do not know whether any molecular motion is concerned in the manifestation of energy which we call electrical. All that we can truly say is, we have

a healthy distrust of our theories, and an abiding faith in that pillar of cloud by day and the pillar of fire by night—the doctrine of the conservation of energy.

Having thus outlined the present condition of our knowledge, and of our comprehension of the bearing and tendencies of physical science, let us strive, with the most powerful instruments we have, to survey the promised land which is undoubtedly to be the possession of those who come after us. It is one thing to become familiar with all the applications of the mechanical theory of electricity, and another to make an advance in the subject so that we can see the relations of electrical and magnetic attraction to the attraction of gravitation and to what we call chemical attraction. To this possible relationship I wish to call your attention to-day.

I am forced to believe that the new advances in our knowledge of electrical manifestations are to come from a true conception of the universality of electrical manifestations, and from the advance in the study of molecular physics. Picture to yourselves the position of an investigator in this world. A person on the moon could only conceive of this audience as a molecule made up of many atoms. He could not measure the energy you manifest by moving about—the heat energy —the electrical energy due to the friction of your envelopes. Indeed, he could only suppose your existence, just as we imagine the existence of a molecule of a crystal. Now, the distances we force molecules apart by many of our chemical processes seem extremely small to us; but how immense they really are compared with the distances apart of the atoms! Is it not as if we should take a stone from the moon or from Venus and place it upon the earth in the time of one second? You can imagine, from the familiar spectacle of a meteor, the heat and the electricity that would result. Yet, in respect to relative distances, do we not do something similar when we break a crystal or pour acid upon a metal, or strike a dynamite-cartridge? We are infinitely small ourselves compared with the great universe about us; yet our task is to comprehend the motions of aggregations of atoms infinitely smaller than that aggregation which we call man.

When we break a crystal mechanically, we have a development of electricity. When we heat certain crystals—tourmaline, for example —besides the strain among the molecules of the crystal which is produced by the increased rates of vibration, we have a difference of electrical potential. When we let an acid fall from the surface of a metal, the metal takes one state of electrification and the drop of acid the other—in other words, we produce a difference of electrical potential. On the other hand, a difference of electrical potential modifies the aggregation of molecules. The experiments of Lippman are well known to you. He has constructed an electrometer, and even an electrical machine, which depend upon the principle that the superficial energy of a surface of mercury covered with acidulated water is modified

when a difference of electrical potential is produced at the limiting surfaces. I have lately noticed a striking illustration of the modification of superficial energy by a difference of electrical potential. The experiment can be performed in this way: Fill the lower part of a glass jar with clean mercury, pour a saturated solution of common salt upon the mercury, hang in the salt solution a carbon plate, and connect this plate with a battery of four or five Bunsen cells; and, on connecting an iron wire with the other pole of the battery, touch the surface of the mercury. An amalgam will be speedily formed and chlorine gas given off. After a slight film of this amalgam has been formed on the mercury, remove the iron wire, and then immerse it slowly in salt-and-water. Even at a distance of six inches from the mercury, and far below the carbon electrode, the surface of mercury will be disturbed by the difference of electrical potential, and a commotion, which might be called an electrical storm, will be observed upon its surface. Now, these manifestations of what is called superficial energy—that is, the energy manifested at the surface of separation of any two media, and the effect of electricity upon this superficial energy—afford, it seems to me, much food for thought. There have always been two parties in electricity—one which maintains that electricity is due to the contact of dissimilar substances, and the other party which believes that the source of electrical action must be sought in chemical action. Thus, according to one party, the action of an ordinary voltaic cell is due to the contact, for instance, of zinc with copper, the acid or solution of the cell merely acting as the connecting link between the two. According to the other party, it is to the difference of chemical action on the two metals of the connecting liquid that we must attribute the rise and continuance of the electrical current. It has always seemed to me that these two parties are like the knights in the story, who stood facing opposite sides of a shield, each seeing but one side, one protesting that the shield was silver and the other that it was gold, whereas it was both silver and gold.

The electro-motive force of a voltaic cell is undoubtedly due to the intrinsic superficial manifestation of energy. When two dissimilar metals are placed in connection with each other, either directly or through the medium of a conducting liquid, the chemical action of the liquid brings new surfaces of the metals constantly in contact. Moreover, we have the difference of superficial energy between the liquid and the two metals. So that our expression for electro-motive force is far from being a simple one; it contains the sum of the several modifications of superficial energy at the surfaces of the two metals, and at the two boundaries of the liquid and the metals.

Let us turn now to the subject of thermo-electricity. Here we have again a development of electro-motive force by the mere contact of two metals, when the junctions of the metals are at different temperatures. There is no connecting liquid here, but the surface of one

metal rests directly upon that of the other. The electrical current that arises is due to the difference of superficial energy manifested at the surfaces of the two junctions. We know that the action is on the surface, for the dimensions of the junctions do not affect the electro-motive force. Suppose that we should make the metals so thin that an ultimate molecule of iron should rest against an ultimate molecule of copper. Should we not arrive at a limit, at a definite temperature of the conversion of molecular vibration into electrical energy, and, also, when our theory is perfected, of the number of molecules along a linear line of copper against a linear line of zinc which can produce a current of electricity of a given strength? I have often thought that the jostling, so to speak, of these ultimate molecules of two metals at definite temperatures might form a scientific unit of electro-motive force in the future science of physical chemistry. Look at the great field for investigation there is in the measurement of what we call electro-motive force, both in voltaic electricity and in thermo-electricity. The astronomer measures the positions of the stars and their light, and tabulates the enormous volumes of results from year to year, in order to ascertain some great law or laws of the possible changes of the entire stellar universe—some sweeping onward through space. Is it not fully as important that, in our physical laboratories, we should organize our routine work, and provide some great generalizer, like Sir Isaac Newton, with sufficient data of electro-motive force, or, as I prefer to call it, the relations of superficial energy, in order that the relations between this energy and the ultimate motions of the molecular worlds may become better known to us?

When the world was evolved from the first nebulous stage, a portion of the atoms remained more or less free in the gaseous state, another portion became more or less limited in organic forms, and another portion were tightly compressed into solids more or less elastic. This elasticity is thought by some to be an evidence of very rapid motion through all these various aggregations of matter—or shall we say different manifestations of motion? for some also believe that our ideas of matter result merely from a perception of motion. Shall we affirm that there is some relation between elasticity and electricity? I do not think that we are prepared to do so, for some elastic bodies are good conductors and some are poor conductors of electricity. We can see dimly, however, that there is a great field in molecular physics, in which elasticity and superficial energy and difference of electrical potential shall be treated together.

I have tried various experiments upon the electro-motive force of alloys. By means of an alloy we can apparently modify the superficial energy at the surface of a solid. Thus, an alloy with a parent metal will give a varying electro-motive force. If we could be sure that an alloy is always a definite chemical composition, and not a more or less mechanical admixture, it seems as if we could get closer

to the seat of electro-motive force by a number of quantitative measurements. Unfortunately, the physical nature of alloys is not definitely known, and there is little coherence or regularity in our measurements of their electro-motive force. Still, there is a great field in the study of the electro-motive force of alloys. We can modify the superficial energy of metals, not only by melting metals together, but also by grinding them to a very fine powder, and compressing them again by powerful means into solids more or less elastic, and then examining their superficial energy, which is manifested as electro-motive force. I am still engaged upon researches of this nature, and, if the work is not brilliant, I hope that it will result in the accumulation of data for future generalization.

We can not treat the manifestation of electro-motive force in the voltaic cell apart from the manifestation of electro-motive force in the differently heated junctions of a thermo-electric junction. In both cases there is a difference of manifestation of superficial energy; and in thermo-electricity we can also modify this energy by making alloys. The subject of thermo-electricity has been eclipsed by the magnificent development of the dynamo-electric machine, but we may return to thermo-electricity as a practical source of electricity. I have been lately occupied in endeavoring to modify the difference of potential of two thermo-electric junctions, by raising one junction to a very high temperature under great pressure; for it is well known that the melting-point of metals is raised by great pressure. If the metal still remains in the solid state under great temperature and great pressure, can we not greatly increase the electro-motive force which results from the difference of superficial energy manifested at the two junctions?

When an electrical current is passed through two thermo-electric junctions, it cools the hot one and heats the cool one. Moreover, you are well acquainted with Thomson's discovery that a current of electricity, in passing through a metal, carries heat, so to speak, with it—in one direction in iron and in another in copper. Do we not see here a connection between the manifestation of superficial energy in liquids and the effect of a difference of potential upon it, and the manifestations of thermo-electro-motive force and the effect of differences of electrical potential? It is curious and suggestive that, in applying the reasoning of Carnot's cycle to the effect of a difference of electrical potential on the superficial energy at the surface of separation of two liquids, one is led to the equations which express in thermodynamics the Peltier and Thomson effects.

In thus looking for the seat and origin of electrical action, how much have we discovered? It is evident that our knowledge of electricity will increase with our knowledge of molecular action, and our knowledge of molecular action with that which we call attractive force. It is somewhat strange that, although we are so curious in

regard to electricity, we seldom reflect that gravitation is as great a mystery as electrical attraction. What is this force which acts instantly through space, and which holds our entire solar system together? We know only its simple law — that it attracts bodies directly as their masses and inversely as the square of their distance; but we do not know what relation it bears to electrical force or magnetic force. Here is a field in which we are to push back our boundary of electrical knowledge. I will not call it electrical knowledge, but rather our knowledge of the great doctrine of the conservation of energy. What is the relation between electricity, magnetism, and gravitation, and what we call the chemical force of attraction? It seems to me that this is the question which we must strive to answer; but, when this question is answered, shall we not be as far as ever from the answer to the question, "What is electricity?"

The question of the connection between electricity and gravitation dwelt much in Faraday's thoughts. It is interesting to recall the experiments which he instituted to discover if there is any connection between these great manifestations of force. In his first experiment he suspended vertically an electro-magnet, which was connected with a delicate galvanometer, and let various non-magnetic bodies, such as brass bodies, pieces of stone and crystals, fall through the center of this electro-magnet, thinking that there might possibly be a reaction from the influence of gravitating force on the falling body which would be manifested as an electrical current. He did not, however, obtain the slightest electrical disturbance which might not have been caused by simple electrical induction. He then arranged a somewhat complicated piece of apparatus by means of which a body could be moved alternately with the direction of gravitation and against it, and the terminals of a galvanometer were so connected that the intermittent effects, if they existed, could be integrated or summed up. He failed, however, to find the slightest relation between gravitation and electricity, and he closes his account of his experiments with these words: "Here end my trials for the present. The results are negative. They do not shake my strong feeling of the existence of a relation between gravity and electricity, though they give no proof that such a relation exists."

Since Faraday's time no connection or relation has been found except in the similarity of the law of inverse squares. I have often reflected upon these experiments of Faraday, and have asked myself, Was the direction in which he experimented the true direction to look for a possible relation; and can not the refined instruments and methods of the electrical science of the present aid us in more promising lines of research? Should we not expect that, when two balls of copper, for instance, are suddenly removed from each other, a difference of electrical potential should manifest itself, and that the electrical force thus developed should be opposed to our endeavor to

overcome the attractive force between the masses of copper? Moreover, when we force the copper balls together, should we not expect that an electrical charge should be developed of such a nature as to oppose our motion? And thus in these mutual relations, which are apparently consistent with the doctrine of the conservation of energy, should we not expect to find the relation which we are in search of? Our experiment, therefore, would have to be conducted in this way: We should carefully insulate our two copper masses, estimate the effects that would be due in any way to cutting the magnetic lines of force of the earth, and then with a delicate electrometer, the masses having been placed in a vacuum to get rid of the effect of friction of the air, we should proceed to test their electrical relations. This experiment also gives negative results, but may we not try it under better conditions than I have been able to devise? If we could prove that whenever we disturb the relative position of bodies, or break up the state of aggregation of particles, we create a difference of electrical potential, and, moreover, if we could discover that the work that this electrical potential can perform, together with the heat that is developed by the process, is the complete work that is done on the system against attractive force, whether expressed in gravitation attractive force, or as so-called chemical attractive force, we should greatly extend our vision of the relation of natural phenomena. In thus pursuing the line of argument of my address, I venture to state an hypothetical law which it seems to me is at least plausible in the present state of electrical science, and may serve as a scaffolding to be taken down when experiment shall have properly proportioned the edifice.

This hypothetical law I should state as follows: "Whenever the force of attraction between masses or molecules is modified in any way, a difference of electrical potential results."

In what I may therefore call the physical chemistry of the future, may we not expect that in the reactions we must express the equivalent of the difference of electrical potential in the summation of the entire work which is done? I can make my meaning clearer by referring to an experiment of Hirn by which he obtained a fair value for the mechanical equivalent of heat. In principle it is this: A heavy weight falls upon a lead vessel which contains a given amount of water at a definite temperature. The lead vessel suffers compression by the blow, and the water is raised in temperature. It is found, on properly estimating the amount of heat taken up by the lead and the loss radiated during the experiment, that the heat produced by the blow is the equivalent of its mechanical work. Suppose now that the vessel containing the water should be made of two metals of about the same specific heat or capacity for absorbing heat, and suppose that wires should connect the two different metallic portions with a similar vessel containing water. We should have here two thermo-electric junctions at the same temperature. When the weight falls upon one junction and

heats it with its contained water, we have not only the heated water but also an electrical current; it is evident, therefore, that we should be able to heat the water more when the wire between the two vessels is cut, than when there is a metallic circuit between them, for a part of the energy of the falling weight has become converted into an electrical current. At the terminals of the cut wires there is a difference of electrical potential created for an instant, which, however, instantly disappears. What is the equivalent of the disappearance of this difference of potential? Is it not in the closed circuits through the masses of the metals, a part of which, it is true, becomes sensible heat, but another portion may become latent heat or do internal work among the molecules?

Moreover, is it not reasonable to suppose that certain anomalies which we now find in the determinations of specific heats of complicated aggregation of molecules are due to our failure to estimate the electrical equivalent of the movements and interchanges of the molecules? Let us take, again, the case of friction between two pieces of wood: is it not possible that the friction is the electrical attraction which results from the endeavor to move the adjoining particles of wood in the two pieces asunder? Let us remember, in our endeavor to connect the phenomenon of superficial energy with electrical manifestations, that the friction between two surfaces is modified by keeping these surfaces at a difference of electrical potential. In Edison's motophone, by means of which the voice of one speaking in New York could be made audible to this audience, we see this exemplified in a very striking manner. A platinum point connected with one pole of a battery rubs upon a revolving cylinder of chalk, which is simply moistened with water and is connected with the opposite pole of the battery. The friction between the two is modified in unison with the changes in electrical potential of the battery; and a diaphragm in connection with the platinum point responds to these changes in the friction, and therefore to a transmitter placed anywhere in the electrical circuit.

My own studies have been chiefly in the direction of thermo-electricity, and in the subject of the electrical aspect of what we call superficial energy. I think there is a great field here—in which a large crop of negative results can be reaped—but these negative results I can not regard entirely as thistles. I have tried the following experiment, on the hypothesis that an electrical difference of potential in changing the relations of molecules might modify the heat that is radiated from a surface. I have endeavored to discover whether an electrical current first cools a conductor before it heats it, as we might expect if the molecules being restrained in any way could not radiate as much energy into space as they could under the same difference of temperature, when not submitted to the action of an electrical difference of potential. I have reaped only a thistle so far from this investigation, but I shall

continue it. I have deposited copper in the magnetic field and outside the magnetic field, and have endeavored to ascertain the thermo-electric relations of these layers of copper, and have apparently discovered—I say apparently, for such experiments require a large number of trials, and I have made thus far only a limited number—that there is a difference of superficial energy between the surface in which the molecules of copper have been subjected to a strong attractive force while they were being deposited, and those molecules which have been only under the influence of ordinary gravitation force.

The experiments which I have tried have continually deepened in me the belief that any change in the state of aggregation of particles—in other words, any change which results in a modification of attracting force—whether gravitative or the commonly called chemical attracting forces, results in an electrical potential; and, conversely, that the passage of electricity through any medium produces a change of aggregation of the molecules and atoms. Professor Schuster, in a late number of "Nature" (July 3, 1884, page 230), gives some of the results of his recent investigation of gases subjected to electrical discharges, and believes himself justified in making the following hypothesis: "In a gas the passage of electricity from one molecule to another is always accompanied by an interchange of the atoms composing the molecule; the molecules are always broken up at the negative pole," and in his comments upon this law he remarks that a molecule of mercury consists of a single atom; but mercury has a very brilliant spectrum: this would seem to militate against the hypothesis. On the other hand, if an essential part of the glow discharge is due to the breaking up of the molecules, we might expect mercury-vapor to present other and much simpler phenomena than other vapors. This is the case, for if mercury-vapor is sufficiently free from air, the electrical discharge through it shows no negative glow, no dark spaces, and no stratifications. In reflecting upon experiments of this nature, can not we believe that, if we could systematically break up the arrangement of the atoms in the molecules of any substance, we could produce a difference of electrical potential? Our instrumental means are probably too coarse to enable us to follow the track of such splitting of the molecules. We are like blind men in a great field of energy striving to ascertain the configuration about us with only three senses—the galvanometer sense, the electrometer sense, and the voltameter sense. Suppose you add to the equipment of such blind men a magnetic sense, or an attractive-force sense. Suppose such a blind man could perceive the equivalence of our thoughts in electrical and magnetic relations, as we now see a manifestation of equivalence of mechanical work when a lighthouse lamp bursts upon our sight. Suppose such a person could become sensible of every change among atoms and molecules. Suppose that the quick passing of what we call life from the body into another shape or state of existence should be sensible as a reaction in

electrical and magnetic effects. Such a person could then see the quick ebb and flow and interchanges of attractive forces as we now see the play of colors. Have you ever reflected that we may possibly have some day an electrical spectrum—perhaps I should call it an attracting-force spectrum—in which the electro-magnetic manifestations of energy shall be spread out and differentiated, just as that part of the energy which we receive from the sun and which we call light and heat is now dispersed in the visible solar spectrum? We regard to-day the manifestations of the different colors of bodies—the tints of the objects in the room—as the visible expression of the great law of conservation of energy. The energy which we have received from the sun is making interchanges and is modified by the different molecular structure of the different objects. Thus, a red body has absorbed, so to speak, certain wave-lengths of energy, and has transmitted or reflected back only the red or long waves of energy. The rest of the energy has been devoted to molecular work which does not appeal to us as light or even in certain cases as heat. If we suppose that radiant energy is electro-magnetic, can not we suppose that it is absorbed more readily by some substances than by others, that its energy is transformed so that with the proper sense we could perceive what might be called electrical color; or, in other words, have an evidence of other transformations of radiant energy other than that which appeals to us as light and color?

I have thus far conducted you over a field that, in comparison with what lies before us, seems indeed barren and churlish of results. Have we, then, nothing upon which we can congratulate ourselves? I can only reply by pointing to the rich practical results which you can see in the fine electrical exposition which we owe to the energy and liberality of the citizens of Philadelphia. Although we must glory in this exposition, it is the duty of the idealist to point out the way to greater progress and to greater intellectual grasp.

Perhaps we have arrived at that stage in our study of electricity where our instruments are too coarse to enable us to extend our investigations. Yet how delicate and efficient they are! Compare the instruments employed by Franklin, and even by Faraday, with those which are in constant use to-day in our physical laboratories. Franklin, by the utmost effort of his imagination, could not conceive, probably, of a mirror-galvanometer that can detect the electrical action of a drop of distilled water on two so-called chemically pure platinum plates, or of a machine that can develop from the feeble magnetism of the earth a current sufficiently strong to light the city of Philadelphia. Let him who wanders among the historical physical instruments of many of our college collections stand before the immense frictional electrical machine of Franklin's day, or gaze upon the rude electrometers and galvanometers of that time, and contrast Franklin's machine with the small Toepler-Holtz electrical machine which with a tenth

of the size gives a spark ten times as strong as Franklin's; or the electrometers and galvanometers of Faraday with the mirror-galvanometers and electrometers of Sir William Thomson. Yet, at the same time, let such an observer think of the possibilities of the next fifty years, for the advance of science is not in a simple proportion to the time, and the next fifty years will probably see a far greater advance than the one hundred years since the date of Franklin's electrical work has seen. Is not the state of our imagination like that of the shepherd-boy who lies upon his back, looking up at the stars of heaven, and trying to imagine what is beyond the stars? The only conclusion is that there is something far more than we have ever beheld. Is not the physicist of the future to have instruments delicate enough to measure the heat equivalent of the red and the yellow, the blue and the violet rays of energy?—instruments delicate enough to discover beats of light as we now discover those of sound—an apparatus which will measure the difference of electrical potential produced by the breaking up of composite grouping of molecules? The photographer of to-day speaks, in common language, of handicapping molecules by mixing gums with his bromide of silver, in order that their rate of vibration may be affected by the long waves of energy. Shall we not have the means of obtaining the mechanical equivalent of such handicapped vibrations? Or, turning to practical science, let us reflect upon the modern transmitter and the telephone, and contrast these instruments with the rude, so-called lover's telephone, which consists of two disks connected by a string or wire. What an almost immeasurable advance we see here! Would it not have been as difficult for Franklin to conceive of the electrical transmission of speech as for the shepherd-boy to conceive of other stars as far beyond the visible stars as the visible stars are from the earth?

Yes, we have advanced; but you will perceive that I have not answered the question, which filled the mind of Franklin, and which fills men's minds to day, "What is electricity?" If I have succeeded in being suggestive, and in starting trains of thought in your minds which may enlighten us all upon this great question, I have indeed been fortunate.

CHILIAN VOLCANOES, ACTIVE AND EXTINCT.

By KARL OCHSENIUS.

THE products of the extinct and the still active volcanoes of Chili, of which Pissis enumerates not less than seventy, are of contemporary origin with the diluvial and alluvial strata of the country. Of the gaseous emissions of their craters, it need only be mentioned that, as in all American volcanoes, chlorine is weakly represented. The

vapors consist chiefly of carbonic acid, sulphur compounds, and water. The present solid products do not differ greatly in composition from the trachytes of the past. Audesite, or a feldspathic mineral very nearly like it, is an important constituent of the porphyritic lavas of both active and quiet volcanoes. Olivine is found in the older and in the more recent lavas of Descobezado, Antuco, and Osorno, as well as in those of Juan Fernandez, and very probably in the liquid outflows of all the other craters. Other lavas occur, among them obsidian, pearl-stone, pitch-stone, and pumice, the last being quite abundant in the Cordilleras of Talca and Chillan. Lapilli cover the eastern flank of Osorno to a depth of about sixteen feet, and through it rose as late as 1851 the great, strong-limbed trunks of dead trees, whose thickness indicated an age of about one hundred and fifty years, while it had been about fifty years since the last eruption of the mountain. But it was a laborious task to trace the lava-stream under the flourishing new growth that had taken root in the weathered surface and in the crevices of the hard deposit.

Of the still active volcanoes, we may say that Atacama emitted smoke after the earthquake of May, 1877. The group of San José was active in 1833, threw rocks into the valley of Pinquenes in 1843, and has been again active since the 2d of March, 1881. Numerous crater-openings, with ancient lava-flows, are found in the same region. Tinguiririca, to the south of this region, consists almost wholly of trachyte, and has several solfataras about five thousand feet below its summit, whence issue vapors having a temperature of 194°; its thick deposit of sulphur has caused it to be given the name of Morro de Azufre, or Sulphur Mountain. More important still is the volcano of Petesoa, at the outbreak of which, on the 3d of December, 1762, the district was desolated with lava and ashes, and the Rio Lontue was dammed up for ten days. Its last eruption, in February, 1837, was followed by destructive floods in the lower-lying regions, caused by the sudden melting and precipitation of the snows from its summit. An immense horizontal ice-cap now lies in the crater, whence rise vertically isolated columns of smoke that can be seen from a considerable distance. Beyond this is the volcanic center of Descobezado, in the southern part of which a solfatara opened in 1847 that kept the district trembling for many years.

The present region of active commotion begins at 36° 50′ with the volcano of Chillan. A new crater opened northeast of the principal peak of this mountain on the 2d of August, 1861, the flow from which melted the snow and caused great floods. The streams, saturated with ashes, became rivers of mud, and covered the plains with a coating of black. The crater did not become quiet for a year, and then only to break out again in 1864 with increased violence. The dark column of smoke that rose from the crater was visible for miles around, the ash-rain was more formidable than in 1861, and the detonations were

heard and window-sashes were shaken at Concepcion. After a short period of rest, in January, 1865, its activity was again resumed. Antuco is only a few miles south of Chillan. It was visited by Pöppig in 1827, and by Domeyko in 1845, while it was in full activity, and it still sends up faint columns of smoke. The Imperial, or Yaima, in Araucania, was in action in 1852 and 1864, but has since not given any sign of an eruption. An eruption was observed in Villarica about 1860, but nothing since; and the fact that the snow on the top of the mountain does not exhibit any marks of change indicates that its forces are weak. Next to this volcanic center comes Osorno, to which may be added others farther south that have not yet been accurately observed. Among these is one at the southern end of Middle Island, in the Strait of Magellan, which the men of the English ship-of-war Penguin saw at the end of 1877 in full activity. Heavy subterranean rumblings are no rarity in any part of Chili.

In all only ten known Chilian craters can be pronounced with certainty to be now active volcanoes. Obviously the neighborhood of these subterranean furnaces can not be regarded as belonging to the quiet regions of the earth. No part of the earth's surface is so prolific of earthquakes as the western half of South America; and here they are more frequent and severe on the Pacific coast than on the eastern side of the Andes. On this coast they are often accompanied with scenes of horror and woe that surpass description. To the direct consequences in the loss of life and the destruction of buildings are frequently added the ravages of fire breaking out in the ruins and consuming all that has not been already crushed. The seaport towns are exposed to a still further danger of destruction by the rushing tidal-wave which follows the extraordinary retreat of the waters with which the earthquake phenomena are usually accompanied. These evils and more were suffered in their worst form during and after the earthquakes of March, 1881, with which Mendoza was visited, and August, 1868, which laid waste a considerable stretch of the coast, with many towns.

With these volcanic and seismic phenomena is associated a steady elevation of the Chilian coast, which has amounted, according to the indications of the shore-terraces, to from six metres at Cape Three Mountains, to three hundred and ninety-seven metres at Concepcion, within the present geological period. Darwin has averaged the rate at about seventeen centimetres a year. The Island of Santa Maria, in the northwest of the Bay of Arauco, rose three metres during the earthquake of 1835, but afterward sank to its old level. Depressions also seem to have taken place in former periods. The elevating force is more intensive in the Chilian Andes than in the neighboring countries, and, as it is still in operation, it is destined probably to carry the loftiest peaks of the Cordilleras to a still greater height. The frequent occurrence of the ending *huapi*—Indian for island—in the names of

promontories, indicates that many former islands are now connected with the mainland. The islands of Imeleb and Quehui, in Chiloe, are at present separated only at high water, and appear to be approaching a permanent union.—*Translated for the Popular Science Monthly from Die Natur.*

THE CHEMISTRY OF COOKERY.

By W. MATTIEU WILLIAMS.

XXXVIII.—COUNT RUMFORD'S COOKERY.

IN my last I referred to Rumford's anticipation of the results of modern chemical analysis in his selection of the materials for his economical feeding of the poor of Munich; but, as may be supposed, all his theoretical speculations have not been confirmed. The composition of water had just been discovered, and he found by experience that a given quantity of solid food was more satisfying to the appetite and more effective in nutrition when made into soup by long boiling with water. This led him to suppose that the water itself was decomposed by cookery, and its elements recombined or united with other elements, and thus became nutritious by being converted into the tissues of plants and animals.

Thus, speaking of the barley which formed an important constituent of his soup, he says: "It requires, it is true, a great deal of boiling; but, when it is properly managed, it thickens a vast quantity of water, and, as I suppose, *prepares it for decomposition*" (the italics are his own).

We now know that this idea of decomposing water by such means is a mistake; but, in my own opinion, there is something behind it which still remains to be learned by modern chemists. In my endeavors to fathom the *rationale* of the changes which occur in cookery, I have been (as my readers will remember) continually driven into hypotheses of hydration, i. e., of supposing that some of the water used in cookery unites to form true chemical compounds with certain of the constituents of the food. As already stated, when I commenced this subject I had no idea of its suggestiveness, of the wide field of research which it has opened out. One of these lines of research is the demonstration of such true chemical hydration of cooked gelatine, fibrine, cellulose, casein, starch, legumin, etc. That water is *with* them when they are cooked is evident enough, but that water is brought into actual chemical combination with them in such wise as to form new compounds of additional nutritive value proportionate to the chemical addition of water demands so much investigation that I have been driven to merely theorize where I ought to demonstrate.

The fact that the living body which our food is building up and

renewing contains about eighty per cent of water, some of it combined, and some of it uncombined, has a notable bearing on the question. We may yet learn that hydration and dehydration have more to do with the vital functions than has hitherto been supposed.

The following are the ingredients used by Rumford in "Soup No. 1":

	Weight, avoirdupois.		Cost.		
	lbs.	ozs.	£	s.	d.
4 viertels of pearl-barley, equal to about 20½ gallons	141	2	0	11	7½
4 viertels of peas	131	4	0	7	3½
Cuttings of fine wheaten bread	69	10	0	10	2½
Salt	19	13	0	1	2½
24 maass, very weak beer, vinegar, or rather small beer turned sour—about 24 quarts	46	13	0	1	5½
Water about 560 quarts	1,077	0			
	1,485	10	1	11	9
Fuel, 88 pounds of dry pine-wood			0	0	2½
Wages of three cook-maids, at 20 florins a year each			0	0	3½
Daily expense of feeding the three cook-maids, at 10 kreutzers (3 pence ½ sterling) each, according to agreement			0	0	11
Daily wages of two men-servants			0	1	7½
Repairs of kitchen furniture (90 florins per annum) daily			0	0	5½
Total daily expenses when dinner is provided for 1,200 persons			1	15	2½

This amounts to $\frac{422}{1200}$, or a trifle more than one third, of a penny for each dinner of this No. 1 soup. The cost was still further reduced by the use of the potato, then a novelty, concerning which Rumford makes the following remarks, now very curious: "So strong was the aversion of the public, particularly the poor, against them at the time when we began to make use of them in the public kitchen of the House of Industry in Munich, that we were absolutely obliged, at first, to introduce them by stealth. A private room in a retired corner was fitted up as a kitchen for cooking them; and it was necessary to disguise them, by boiling them down entirely, and destroying their form and texture, to prevent their being detected." The following are the ingredients of "Soup No. 2," with potatoes:

	Weight, avoirdupois.		Cost.		
	lbs.	ozs.	£	s.	d.
2 viertels of pearl-barley	70	9	0	5	$9\frac{1}{2}\frac{1}{3}$
2 viertels of peas	65	10	0	3	$7\frac{1}{2}$
8 viertels of potatoes	230	4	0	1	$9\frac{3}{11}$
Cuttings of bread	69	10	0	10	$2\frac{4}{11}$
Salt	19	13	0	1	$2\frac{1}{2}$
Vinegar	46	13	0	1	$5\frac{1}{2}$
Water	982	15			
Fuel, servants, repairs, etc., as before			0	3	$5\frac{4}{12}$
Total daily cost of 1,200 dinners			1	7	$6\frac{1}{2}$

This reduces the cost to a little above one farthing per dinner—$1\frac{1}{10}$ exactly.

In the essay from which the above is quoted, there is another account, reducing all the items to what they would cost in London in November, 1795, which raises the amount to $2\frac{3}{4}$ farthings per portion for No. 1, and $2\frac{1}{2}$ farthings for No. 2. In this estimate the expenses for fuel, servants, kitchen furniture, etc., are three times as much as the cost at Munich, and the other items at the prices stated in the printed report of the Board of Agriculture of November 10, 1795.

But since 1795 we have made great progress in the right direction. Bread then cost one shilling per loaf, barley and peas about fifty per cent more than at present, salt is set down by Rumford at $1\frac{1}{4}d.$ per pound (now about one farthing). Fuel was also dearer. But wages have risen greatly. As stated in money, they are about doubled (in purchasing power, i. e., real wages, they are threefold). Making all these allowances, charging wages at six times those paid by him, I find that the present cost of Rumford's No. 1 soup would be a little over one halfpenny per portion, and No. 2 just about one halfpenny. I here assume that Rumford's directions for the construction of kitchen fireplaces and economy of fuel are carried out. We are in these matters still a century behind his arrangements of 1790, and nothing short of a coal-famine will punish and cure our criminal extravagance.

The cookery of the above-named ingredients is conducted as follows: "The water and pearl-barley first put together in the boiler and made to boil, the peas are then added, and the boiling is continued over a gentle fire about two hours; the potatoes are then added (peeled), and the boiling is continued for about one hour more, during which time the contents of the boiler are frequently stirred about with a large wooden spoon or ladle, in order to destroy the texture of the potatoes, and to reduce the soup to one uniform mass. When this is done, the vinegar and salt are added; and, last of all, at the moment that it is to be served up, the cuttings of bread." No. 1 is to be cooked for three hours without the potatoes.

As already stated, I have found, in carrying out these instructions, that I obtain a *purée* or porridge rather than a soup. I found the No. 1 to be excellent, No. 2 inferior. It was better when very small potatoes were used; they became more jellied, and the *purée* altogether had less of the granular texture of mashed potatoes. I found it necessary to conduct the whole of the cooking myself; the inveterate kitchen superstition concerning simmering and boiling, the belief that anything rapidly boiling is hotter than when it simmers, and is therefore cooking more quickly, compels the non-scientific cook to shorten the tedious three-hour process by boiling. This boiling drives the water from below, bakes the lower stratum of the porridge, and spoils the whole. The ordinary cook, were she "at the strappado, or all the racks in the world," would not keep anything barely boiling

for three hours with no visible result. According to her positive and superlative experience, the mess is cooked sufficiently in one third of the time, as soon as the peas are softened. She don't, and she won't, and she can't, and she sha'n't understand anything about hydration. "When it's done, it's done, and there's an end to it, and what more do you want?" Hence the failures of the attempts to introduce Rumford's porridge in our English workhouses, prisons, and soup-kitchens. I find, when I make it myself, that it is incomparably superior and far cheaper than the "skilly" at present provided, though the sample of skilly that I tasted was superior to the ordinary slop.

The weight of each portion, as served to the beggars, etc., was 19·9 ounces (one Bavarian pound); the solid matter contained was 6 ounces of No. 2, or 4¾ ounces of No. 1, and Rumford states that this "is quite sufficient to make a good meal for a strong, healthy person," as "abundantly proved by long experience." He insists, again and again, upon the necessity of the three hours' cooking, and I am equally convinced of its necessity, though, as above explained, not on the same theoretical grounds. No repetition of his experience is fair unless this be attended to.

The bread should *not* be cooked, but added just before serving the soup. In reference to this he has published a very curious essay entitled "Of the Pleasure of Eating, and of the Means that may be employed for increasing it," the discussion of which must be postponed until my next, together with the details of the more luxurious *menu* of the first company of the Elector's own grenadiers, who were fed upon boiled beef, soup, and dumplings, at the large cost of twopence per day, and other regiments variously fed at about the same cost.

Before concluding this paper, I must add a few words in reference to the amusing *fiasco* of Mr. Albert Dawson, described in No. 139, p. 486. I scarcely thought it necessary in writing for intelligent people to remind them that the length of time which any kind of moist food may be kept varies with the temperature and the place in which it is kept. Most people know that a leg of mutton, which, on the average, should hang for about a week, may advantageously hang for a month or more in frosty weather, and be spoiled if kept at mid-summer in an ill-ventilated place for two days. The fate of Mr. Dawson's porridge is an illustration of this simple principle. Judiciously kept, it becomes slightly sour; this sourness is due to the conversion of some of the starch into sugar, and the acetous fermentation of some of this sugar. The vinegar thus formed performs the function of that supplied by Count Rumford to his porridge. It renders it more digestible, and assists in its assimilation. The reheating of the oatmeal-porridge drives off any disagreeable excess of acid that may have been formed, as acetic acid is very volatile.

Tastes may vary as regards this constituent. For example, my old friend (to whom I referred), the late William Bragg (so well known

in Birmingham, Sheffield, and South America), preferred his porridge when thus soured; other members of his family say that it lost the original aroma of the oatmeal. Be that as it may, I have no doubt that the ensilaged porridge, ounce for ounce, supplied more nutriment and demanded less work from the digestive organs than the freshly-made porridge. Probably this advantage may be obtainable more agreeably by Rumford's three hours' boiling, and his willful addition of the vinegar.

XXXIX.—COUNT RUMFORD'S DIETETICS.

In the formula for Rumford's soup given in my last, it is stated that the bread should not be cooked, but added just before serving the soup. Like everything else in his practical programmes, this was prescribed with a philosophical reason. His reasoning may have been fanciful sometimes, but he never acted stupidly, as the vulgar majority of mankind usually do, when they blindly follow an established custom without knowing any reason for so doing, or even attempting to discover a reason.

In his essay on "The Pleasure of Eating, and of the Means that may be employed for increasing it," he says: "The pleasure enjoyed in eating depends, first, on the agreeableness of the taste of the food; and, secondly, upon its power to affect the palate. Now, there are many substances extremely cheap, by which very agreeable tastes may be given to food, particularly when the basis or nutritive substance of the food is tasteless; and the effect of any kind of palatable solid food (of meat, for instance), upon the organs of taste, may be increased almost indefinitely, by reducing the size of the particles of such food, and causing it to act upon the palate by a larger surface. And if means be used to prevent its being swallowed too soon, which may easily be done by mixing it with some hard and tasteless substance, such as crumbs of bread rendered hard by toasting, or anything else of that kind, by which a long mastication is rendered necessary, the enjoyment of eating may be greatly increased and prolonged." He adds that "the idea of occupying a person a great while, and affording him much pleasure at the same time, in eating a small quantity of food, may perhaps appear ridiculous to some; but those who consider the matter attentively will perceive that it is very important. It is, perhaps, as much so as anything that can employ the attention of the philosopher."

Further on he adds, "If a glutton can be made to gormandize two hours upon two ounces of meat, it is certainly much better for him than to give himself an indigestion by eating two pounds in the same time."

This is amusing as well as instructive, so also are his researches into what I may venture to describe as the *specific sapidity* of different kinds of food, which he determined by diluting or intermixing them with insipid materials, and thereby ascertaining the amount of surface

over which they might be spread before their particular flavor disappeared. He concluded that a red-herring has the highest specific sapidity—i. e., the greatest amount of agreeable flavor in a given weight of any kind of food he had tested—and that, comparing it on the basis of cost for cost, its superiority is still greater.

He tells us that "the pleasure of eating depends very much indeed upon the *manner* in which the food is applied to the organs of taste," and that he considers "it necessary to mention, and even to illustrate in the clearest manner, every circumstance which appears to have influence in producing these important effects." As an example of this, I may quote his instructions for eating hasty-pudding: "The pudding is then eaten with a spoon, each spoonful of it being dipped into the sauce before it is carried to the mouth, care being had in taking it up to begin on the outside, or near the brim of the plate, and to approach the center by regular advances, in order not to demolish too soon the excavation which forms the reservoir for the sauce." His solid Indian-corn pudding is, in like manner, "to be eaten with a knife and fork, beginning at the circumference of the slice, and approaching regularly toward the center, each piece of pudding being taken up with the fork, and dipped into the butter, or dipped into it *in part only*, before it is carried to the mouth."

As a supplement to the cheap soup receipts given in my last, I will quote one which Rumford gives as the cheapest food which, in his opinion, can be provided in England: Take of water eight gallons, mix it with five pounds of barley-meal, boil it to the consistency of a thick jelly. Season with salt, vinegar, pepper, sweet-herbs, and four red-herrings pounded in a mortar. Instead of bread, add five pounds of Indian corn made into a *samp*, and stir it together with a ladle. Serve immediately in portions of twenty ounces.

Samp is "said to have been invented by the savages of North America, who have no corn-mills." It is Indian corn deprived of its external coat, by soaking it ten or twelve hours in a lixivium of water and wood-ashes.* This coat or husk, being separated from the kernel, rises to the surface of the water, while the grain remains at the bottom. This separated kernel is stewed for about two days in a kettle of water placed near the fire. "When sufficiently cooked, the kernels will be found to be swelled to a great size and burst open, and this food, which is uncommonly sweet and nourishing, may be used in a great variety of ways; but the best way of using it is to mix it with milk, and with soups and broths, as a substitute for bread." He prefers it to bread, because "it requires more mastication, and consequently tends more to prolong the pleasure of eating."

* Such lixivium is essentially a dilute solution of carbonate of potash in very crude form, not conveniently obtained by burners of pit-coal. I will try the commercial carbonate, and report results in my next, stating quantities and other particulars. I have but just come upon this particular soup receipt for the first time.

The cost of this soup he estimates as follows:

	d.
Five pounds barley-meal, at 1½*d.* per pound, or 5*s.* 6*d.* per bushel	7½
Five pounds Indian corn, at 1½*d.* per pound	6½
Four red-herrings	3
Vinegar	1
Salt	1
Pepper and sweet-herbs	2
	1 8½

This makes sixty-four portions, which thus cost rather less than one third of a penny each. As prices were higher then than now, it comes down to a little more than one farthing, or one third of a penny, as stated, when cost of preparation in making on a large scale is included. I have not yet tried this soup. In reference to the others specified in my last, I should add that I found it advantageous to use a double vessel—a water-bath constructed on the glue-pot principle. Such vessels are sold under the name of "milk-scalders."

The reason of this is, that with our ordinary fireplaces the heat is so great that the liability to char the bottom of the thick porridge is a source of trouble. Rumford's fireplaces were so skillfully constructed, and used with just as much wood-fuel as was required to do the work demanded, and thus this difficulty scarcely existed. I have little doubt that one of the reasons why the thin broth of our workhouses and prisons takes the place of his thick soup is, that the liquid stuff demands no skill nor attention from the officials who superintend and the cooks who prepare it. Their convenience is, of course, sacred.

The feeding of the Bavarian soldiers is stated in detail in Volume I of "Rumford's Essays." Space will permit me only to take one example, and that I must condense. It is from an official report on experiments made "in obedience to the orders of Lieutenant-General Count Rumford, by Sergeant Wickelhof's mess, in the first company of the First (or Elector's own) Regiment of Grenadiers at Munich."

JUNE 10, 1795.—BILL OF FARE.

Boiled beef, with soup and bread dumplings.

DETAILS OF THE EXPENSE.

First, for the boiled beef and the soup.

lbs.	loths.		Kreutzers.
2	0	beef	16
0	1	sweet-herbs	1
0	0½	pepper	0½
0	6	salt	0½
1	14½	ammunition bread cut fine	2½
9	20	water	0
Total. 13	10	Cost....	20½

The Bavarian pound is a little less than 1¼ pound avoirdupois, and is divided into 32 loths.

All these were put into an earthenware pot and boiled for two hours and a quarter; then divided into twelve portions of $26\frac{7}{12}$ loths each, costing $1\frac{3}{4}$ kreutzer.

Second, for the bread dumpling.

lbs.	loths.		Kreutzers.
1	13	of fine Semel bread	10
1	0	of fine flour	$4\frac{1}{2}$
0	6	salt	$0\frac{1}{2}$
3	0	water	0
Total. 5	19		Cost.... 15

This mass was made into dumplings, which were boiled half an hour in clear water. Upon taking them out of the water they were found to weigh 5 pounds 24 loths, giving $15\frac{1}{3}$ loths to each portion, costing $1\frac{1}{4}$ kreutzer.

The meat, soup, and dumplings were served all at once in the same dish, and were all eaten together at dinner. Each member of the mess was also supplied with 10 loths of rye-bread, which cost five sixteenths of a kreutzer. Also with 10 loths of the same for breakfast, another piece of the same weight in the afternoon, and another for his supper.

A detailed analysis of this is given, the sum total of which shows that each man received in avoirdupois weight daily:

lbs.	ozs.	
2	$2\frac{14}{100}$	of solids,
1	$2\frac{84}{100}$	of "prepared water,"
3	$5\frac{18}{100}$	total solids and fluids,

which cost $5\frac{1}{16}$ kreutzers, or twopence sterling, very nearly. Other bills of fares of other messes, officially reported, give about the same. This is exclusive of the cost of fuel, etc., for cooking.

All who are concerned in soup-kitchens or other economic dietaries should carefully study the details supplied in these essays of Count Rumford; they are thoroughly practical, and, although nearly a century old, are highly instructive at the present day. With their aid large basins of good, nutritious soup might be supplied at one penny per basin, leaving a profit for establishment expenses; and, if such were obtainable at Billingsgate, Smithfield, Leadenhall, Covent-Garden, and other markets in London and the provinces, where poor men are working at early hours and cold mornings, the dram-drinking which prevails so fatally in such places would be more effectually superseded than by any temperance missions which are limited to mere talking. Such soup is incomparably better than tea or coffee. It should be included in the bill of fare of all the coffee-palaces and such-like establishments.—*Knowledge.*

DOMESTIC ARTS IN DAMARALAND.

By Rev. C. G. BÜTTNER.

THE peoples with whom missionaries have occasion to become acquainted in Damaraland belong to different races; and the materials for a fair ethnological museum might easily be collected at any of the more important places. The agricultural Ovambos and the nomadic Hereros and Ovambandierus belong to the Bantu race, the Namaquas and Bushmen to the yellow Hottentot stock, while the tribe called the mountain Damaras are a black people of doubtful origin. But although these peoples differ variously in their manners and customs, yet the general circumstances of their life are such that they exhibit only a few differences in their technical accomplishments and trade usages. The desert character of the country, which furnishes only scanty means of subsistence, compels a certain meagerness in all that the people undertake. They are contented to have their simplest wants satisfied, and have never found or aspired after elegance. This part of Africa had, moreover, till a few decades ago, preserved its exclusiveness for hundreds and thousands of years. The rainless desert coast offered nothing attractive to the sailor, and even when one had landed on the shore it was almost impossible to penetrate through the wilderness to the interior. As the trade from the interior of the continent likewise hardly reached here, we have to do in this region with a people who until very recently had lived from a remote epoch cut off from the rest of the world. The natives of Damaraland are thus to a certain extent analogous with those primitive people who in prehistoric times lived, as hunters and fishers, in the northern woods, and fought out the struggle for existence in the rudest simplicity.

Little that is really artistic is to be found among them. Vessels are made by every tribe in its peculiar traditional form, by which their origin can be determined at once, and are decorated with a likewise stereotyped zigzag design, which is traced on iron articles with a chisel, and on wooden ones with a burning sharp stick. We may also add that the Bushmen, who are apparently in the lowest degree of civilization, have painted upon the rocks, in both ancient and recent times, hunting scenes representing all kinds of game and hunters in various situations, which betoken considerable talent in grasping and setting forth typical forms. These designs might, in fact, be regarded as works of more civilized Europeans, were it not that they were found in such various parts of the country, and that they were so much alike in their most peculiar features.

One of the striking characteristics of South African art is its deficiency in the perception of the straight and of the right angle. Everything that the people make comes from their hands bent and

oblique. It costs a great deal of trouble to teach a servant even to put a chair straight against the wall. If his attention is called to the fact that things are not in order, he will at once proceed to make them more crooked and askew than they were before. It is almost impossible to teach them European trades like that of the carpenter, in which straight lines are essential; but they succeed well in giving symmetrical forms to any rounded or free handwork.

The making and use of fire may be regarded as one of the primitive arts of mankind. Like the ancients, the Damaras regard fire as something handed down from their ancestors, to be carefully preserved. Every Herero *werst* has its sacred fire, which must never be extinguished, and which is considered the central point of the tribe and the village. There is the chief's own place, the sacred objects are kept by the fire, councils are held and judgments are delivered at it, the venerable ceremonial acts are consummated with its ashes, and from it are taken the coals with which fires are kindled in other houses. Those who go out with the herds to the cattle-stands take with them a brand from the sacred fire; and when a chief dies without direct heirs, or when the sovereignty passes to another line, then the old fire is put out and new fire is brought from the *werst* of the new chief. All the members of a single family or tribe regard themselves as sitting around one fire.

The care of the fire is intrusted to the oldest unmarried daughter of the chief, or, if he has no such daughter, to the maiden nearest related to him. If, by any accident or misfortune, it is extinguished, it must not be relit from another fire, but must be made anew from the beginning. For this purpose two straight sticks of any readily burning wood are taken. A hollow is made in one of the sticks, in which the sharpened end of the other one may be twirled, and some punk or half-rotten wood is put in a groove cut to hold it, to serve as tinder. This stick is held to the ground by the knees, while the other one is turned rapidly back and forth between the open hands. When a spark appears, it is directed upon the tinder, which is then readily blown into a flame. Thus, it is not the rubbed stick, but the tinder, that gives the flame. The natives dislike this work very much, and when on a journey, if they have no other fire apparatus, they take an ignited stick with them, the fire of which they skillfully keep glowing for a long time. At the present time, the Africans, far into the interior, are acquainted with the use of steel and flint and of matches; Jönköping's paraffine-lighters have probably penetrated farther into the heart of Africa than any European explorer. There is no evidence that the people knew anything of the steel and flint before they became acquainted with Europeans; and I have never seen a fire-steel that was made by a native smith. Besides cooking food and warming and lighting the huts, fire is employed for the felling of large trees and the splitting of stones. In the former case, the fire is built around

the root of the tree, and kept burning till the tree falls. One man can attend a considerable number of such fires, so that the work, as a whole, may go on quite fast. Stones which it is desired to remove from the road are split by the aid of fire, and wells are bored through the rock sometimes to the depth of thirty feet or more.

Hardly any stone implements are used by the Africans, and no trace of a stone hammer or a stone knife has been found in the country. The nearest approach to anything of the kind is when the Bushmen and mountain Damaras occasionally bore through a stone, and load their digging-sticks with it. The stick, having been pushed through the hole till the weight is about at its middle, is grasped with one hand below the stone, and with the other hand above it; and is used more advantageously, just as better work can be done with a heavy crow-bar or mattock than with a light one. These stones are of a similar shape with those that are used for net-weights, but are considerably heavier. Fire-wood is broken up by throwing heavy stones upon it. Long stones seem better adapted to this purpose than others, and, when one peculiarly fitted for the work is found, it is generally kept. Flat stones are employed as lower millstones, and a convenient round stone is looked for with which to do the grinding. So far as I know, no art is applied in shaping the millstones, but the upper one naturally becomes more rounded and the lower one more hollow by use, and both are thus better adapted to their purpose. Old grinding-stones are, therefore, more highly prized than new, unused, and rough ones. These grinders resemble to a hair those that were formerly used by the northern peoples. Small, longish stones are used as hammers, but without any handle, being held directly in the hand. The native smiths now prefer the large bolts with which wagon-tongues are fastened; but stones were formerly used exclusively when native metallurgic art was not competent to produce iron tools adapted to hammering.

The use of clay in pottery is well known in Africa, and the potters are familiar enough with the places where the best material can be found. The pots that I have seen have the form of an egg, and will not stand without a support. Before the natives learned from the Europeans to put feet under their vessels, they laid stones around the bottom. The pots were made with the free hand, without a wheel, by adding to a ball of nearly dry clay a roll of similar clay, and then welding the two together, and smoothing them with the moistened hand; then another roll, and another, till the sides of the vessel were extended far enough; and the marks of the joints between the added rolls could usually be distinguished in the finished vessel. The Hereros characterize the method of this process quite strikingly in their expression "to build up a pot," for "to make one." The vessels are never glazed, but, as the people are not particular about cleanliness, they soon become water-tight. They are burned only as much as can

be done in an open fire. Pots of this kind are, however, not much used in Damaraland, iron pots of European manufacture being preferred. Other vessels than cooking-vessels being made of wood, the potter's industry of the country is in a course of rapid extinction.

Iron and copper were the only metals known to the natives before the arrival of the Europeans, and they were both called in the Herero language by the same name. The civilized Hereros now use foreign words for copper, silver, and gold, while lead has received its name from the bullets into which it is cast. The pastoral tribes of the Hereros and Ovambandierus have but few smiths of their own, but are served by itinerant smiths from other tribes, who wander around, working in small companies, among the chiefs, till they have earned enough cattle to justify them in returning to their homes. Sometimes they are political refugees who have excited the anger or jealousy of their chiefs in Ovamboland, and are compelled to turn their backs upon their homes till a change of dynasty takes place. These Ovambo smiths brought iron from their native country, where the art of extracting that metal and copper from the ores is understood, and rich ores are found. Iron could formerly be got in Ovamboland only at the cost of great labor, and the smith then had to carry his store on his back some fifteen or twenty days' journey. The metal, therefore, commanded a very high price. As late as about 1840, a simple bracelet of iron wire was an adequate guest's present, and a large fat wether could easily be bought with a span of the old hoop-iron with which trunks were bound. The natives were greatly astonished at seeing the costly metal wasted by the Europeans in boot-nails. Iron had thus the value of a precious metal, and, rusting and changing but little in the dry climate, was worn in ornaments by the Hereros, while other tribes preferred copper and brass. The native smiths now use European iron, and seek out good steel, such as is found in files and bayonets. But iron forged in the old-fashioned way into ornaments and weapons has still considerable value.

A smith's bellows common to all the Bantu peoples consists of two wooden vessels, out of which the air is pumped into the fire through the long, straight horns of the African gemsbok. The Hottentot bellows, which is more generally used in Damaraland, is a long bag, usually made from the whole hide of a goat, at the middle and the end of which is an air-valve. The fore half of the skin is held to the ground and weighted with a stone to press upon the air, which is pumped in by means of the alternate compression and expansion of the rear half. From the point of the bellows, or neck-end of the hide-bag, the air is conducted through a clay pipe or a gemsbok-horn, or, in later times, a gun-barrel, to the fire. It is obvious that only light work can be done with such a bellows; at most, bringing a small piece of iron to a red heat. For tongs, the smiths generally use a bullet-mold, while they formerly took two straight pieces of iron, or,

if they had nothing better, two sticks. A stone is made to serve as an anvil. Iron beads and bracelets are made, and the last are adorned with some neatly engraved pattern. Some of the rings of which I have obtained specimens, which have been simply turned upon a stick and welded, would do credit to a European smith. I have seen copper bracelets that had been bent into a spiral shape resembling a coiled snake. The Hottentots like bracelets and rings made by winding brass and copper wire around a coil of leather, in which patterns are produced by mingling wires of different sizes. The Ovambos wear heavy copper rings on their ankles, which are bent upon the legs. One of these rings, which I presented to the Ethnological Museum in Berlin, is very like some of the rings that are found in northern graves. Other works of the South African smith's art are iron lances having the handles ornamented with an ox-tail flier, barbed arrow-heads, double-edged knives and daggers, the latter without guards; and axe and hatchet blades, which are now used in making wooden articles. Almost everything that is made of wood has to be formed from a single piece, for the art of permanently joining two pieces of wood together seems to be wanting among these people. They do not know how either to dovetail, nail, or glue. Hence, in making every article of wooden-ware, whether a spoon or a boat, the artificer has to be governed by the shape and size of his block. The knife-cases and dagger-sheaths are thus made from one piece; and, as the natives have no boring-tools, one of the cheeks of the sheath has to be cut entirely away, excepting thin strips at the corners to hold the blade in its place. The tools used for hollowing out the wooden vessels are a double-adze, or *tribill*, and an axe worked like a chisel. The adze is a triangular iron, shaped so as to present a knife-edge at one end and a point at the other, and is driven through a hole previously burned in the handle, perpendicularly to it, and in such a manner that every blow made with the tool in hewing shall drive it tighter up. The outside of the vessel is shaped with the adze; all is done by eye, without any such aids as the square or compass, and nothing but the hands to hold the block while it is hewed. But the work is performed with a skill and finish that would do credit even to a shop provided with the implements of civilized artisans. This kind of work appears to belong to the chief, and to be regarded as a kind of state function; for, although it may not be done by the chief himself, it is generally performed under his eye, at the village fire, and is submitted to his inspection from time to time while it is going on. If a wooden vessel becomes cracked, it is not thrown away, but is mended, if possible, by sewing up, or patching with fibers of tough grass, or of the fan-palm common in the country, and then smeared with cow-dung, a substance which the Africans do not regard as unclean, to make it milk-tight. Round-headed canes, long and short throw-sticks, and arrows of hard wood are carved with knives.

The eastern Bechuanas and Caffres are fond of carving canes entwined with snakes. While the cane and snake are made from the same piece, the latter is attached only at a few points, so that the mass of its body is left free. The wooden arrows, which have barbed heads, are used for shooting small game. Sometimes wooden arrowheads are set loose in shafts of reed, so that, when the latter are drawn out, the points shall remain in the wound.

Rush mats are made by the Hottentots, by stringing rushes on a needle and drawing a thread through them. Threads and cords are made from bark-fibers and fibers of aloe without the aid of any tools, simply by twisting them with the flat hand upon the leg. Baskets are made from roots and from palm-leaves, where that material can be had. The foundation of the basket is laid with a spiral of thick braid, as our straw hats are begun, to which rings are added and connected as compactly as possible by cords, and the vessel is made tight enough to hold milk or any other fluid. Skins are dressed by saturating them with fat, and rubbing and kneading them with the hands and feet till they are perfectly pliable; or, if they are very thick, by beating them with a club. Straps are prepared by cutting them out spirally from the skin, so as to get as great a length as the leather will afford. The strap is then slung over a stout limb, so that its ends will come as near to the ground as they will reach; the ends are weighted with a stone, and the doubled strap is twisted up, with the aid of a lever, as tightly as possible, till the stone is raised nearly up to the limb. The lever is then drawn out, and the strap is allowed to untwist and retwist itself again and again. This process is repeated, with oiling, for several days, till the strap becomes quite pliable. Skins which are to be made into bottles are taken off from the carcass with as little cutting as possible, the knife being generally used only at the tail and the feet, after which the hide is pulled off literally over the ears. The bottles are then tanned in the common manner, but are only used for keeping dry articles. The Hottentots employ bark in tanning skins, but it is possible they learned the art from the Europeans.

Skins are also used for clothing, without any making up, but worn just as they are left after dressing, with at most only a little shell-embroidery, but are not sewed to one another, except when they are to be used for bed-coverings or curtains. Thorns, which grow on the acacias and mimosas, of every shape and size that can be desired, are employed as needles, and for thread the long sinews from the backbones of slaughtered animals, which are stiff enough to be pushed through the hole made by the thorn without any further aid than their own rigidity. In the ante-European times pins, buckles, and hooks were unknown, and the only means of holding the garment upon the person was by a belt, or the hands; or, if a whole sheep-skin was worn as a cloak, the head was left to hang down behind, and the hind-legs were brought over the shoulders and tied.

Shoes were made from the thicker hides. The Hereros wore sandals with long points in front and behind, projecting beyond the foot. The Namaquas wore something more nearly approaching shoes, in which they attached the upper leather to the sole with a narrow strap. The work being done by the eye, without measuring or fitting, it often happened that the shoes of a pair were of different sizes and shapes. I have never seen anything made of bone in South Africa except little mat-needles among the Namaquas, mouth-pieces of pipes, and snuff-boxes. The Namaquas also make pipes from serpentine. Small bones are worn as ornaments and amulets; and little children sometimes have a few bones hanging from their belts for playthings.—*Translated for the Popular Science Monthly from Das Ausland.*

OLD CUSTOMS OF LAWLESSNESS.

By Herr M. KULISCHER.

GRIMM tells, in his "Legal Antiquities of Germany," of a peculiar custom which existed, in the duchy of Carinthia, during the election of a new duke, till a comparatively recent period. So long as affairs continued unsettled, relates the narrative from which he quotes, the Gradnecks had the right, which had come down to them from of old, to mow as much hay as they could, robbers to plunder, and pirates to ravage the land at will with impunity, unless peace was made with them. Leoben states that this custom arose in the time of Charlemagne, about A. D. 790, under Duke Ingo, but further than that its origin is still in the dark. It is impossible to explain the existence of so barbarous a practice as this, by reference to any motive of expediency, as we are usually able to do with the phenomena of political and social life. An outbreak of outrage could evidently respond to no real social want; least of all a usage that must have been destructive, for the time being, of all fundamental conditions of social life, and of the material well-being of the population, and that could not have failed to be detrimental to the maintenance of social order when law was supposed to be again in force. The case is evidently one of a survival from a former period, a relic, perhaps, of some older condition of society. We may probably find a little light concerning its origin in the study of some of the savage tribes of the present time, who are believed by many anthropologists to be living in the same grades of civilization which the ancestors of modern civilized nations have passed through.

We learn from African travelers of the existence by custom, in some of the West African states, of a general anarchy and tolerated hostility during the interregnum between the death of a king and the

enthronement of his successor. When the King of Ashantee dies, his women destroy his treasures, and general unrestricted license, robbery, and murder prevail in the country; and a similar season of disorder ensues on the death of the chief in Whydah, Benin, and other states. Waitz remarks, in his "Anthropology of Savages," concerning the duration and extent of this license: "Usage has limited the anarchy to a definite and short time, and it is admitted by all that the disorder in no way works a real dissolution of all social bonds, but is only to be regarded as a sudden relaxation of them which, notwithstanding that all sorts of outrage are let loose, is always controlled by custom, and induces no material damage to society." In Ashantee, the season of unrestraint may last for five days; in other states it may continue for a considerably longer time, as in Loango, where it prevails for several months. In Dahomey, the death of the king is not made known for eighteen months, while the heir, assisted by the two highest officers, reigns in his name during this whole period. The eighteen months seem to mark the time during which a legal anarchy formerly prevailed, though it may now have been done away with.

We have a right to conclude from these facts that a tolerated disorder is an accompaniment of the death of a ruler, and lasts until the accession of a new one. The eighteen months mentioned above were probably originally an interval of that kind; and, although the deceased ruler is now immediately succeeded by another, the latter still reigns, according to a custom transmitted from that time, not in his own name, but in that of his predecessor, who is not regarded as dead, but only as ineffective. A customary anarchy is also said to have prevailed as a form of mourning after the death of a sub-chief among the Maravis—a fact that agrees with the general explanation of the usage incidentally given by Waitz, who remarks that it "appears to be nothing more than the public mourning of the whole country, which inflicts wounds upon itself as individual relatives afflict themselves after the death of a private person." A similar motive possibly prompts the destruction of the king's jewels by his women in Ashantee, and is perhaps re-enforced by a view which has been observed to prevail in earlier stages of civilization, that all that he possesses dies with the owner. Livingstone speaks of a periodical lawlessness among the Banyai, which ceases upon the election of a new chief. A similar custom prevails among the Wahumas of the lake-region, who have in other respects made considerable advances in civilization. These African peoples stand as a rule at a far lower grade of civilization than the one which the people of the duchy of Carinthia had reached while the custom of legal anarchy as described still existed among them. We are able to study the practice more closely among the African peoples, and make a nearer approach to its origin. Among them it does not appear to be connected with the time when the newly chosen chief ascends the throne, but at an earlier period to have lasted

considerably longer than it does now, or during the whole interval that might have elapsed between the death of a ruler and the accession of a new chief. As such an interval is superfluous in hereditary monarchies, where a successor to the throne is always at hand, we must relegate the origin of the custom to that period of the people's life when the chief obtained his office by election. A connection with election is indicated in the case cited by Grimm and confirmed by Livingstone's relation. If the custom continues after the office has become hereditary, it is evidently only as a survival.

The condition of disorder assumed another form in Tahiti, where, upon the death of the chief, the several districts of the nation made sham wars upon one another, which were sure to end in real plundering. This phase of the custom appears to have been an outgrowth of the federative nature of the state. The bond of union between the provinces having been severed, the mutual jealousies, which always prevail between adjoining communities, broke out in force, and found expression in the singular way that we have indicated. Questions were sure to arise, as to which district should nominate the new chief, that would be certain to generate disturbance. The hostile relations would cease as soon as the new chief was chosen and the federal bond was restored; for the several communities would again be members of the same political body, under a common head, and would be compelled to live in at least outward unity. The custom of legal anarchy in this form, then, appears to be a survival from a condition in which neighboring districts waged constant, real wars with each other, and gave to destruction all the property they could get of their rivals; and its existence in countries where the chiefdom has become hereditary may be regarded as a sign that a federative system, with an elective chief, once existed there. Confirmation of this view is afforded by the existence of a tradition among the Ashantees, where the royal dignity is now hereditary, according to which the nation was once a federation of twelve territories.

It is easy to believe that, in view of the periodical disorders to which federatively constituted states are liable, such forms must give way to more solid ones, as soon as the instinctive, mutual hostility of the allied territories is extinguished, under the continuous operation of an associated life; and that the efforts of powerful families to appropriate the chieftainship to themselves as an hereditary possession will find sympathizers among those who dread the return of a temporary legal anarchy as an accompaniment of each new election. It will, moreover, be important, after the hereditability of the royal office has been accepted, to establish the principle of the uninterrupted existence of that office. According to this principle, the throne is never vacant; or, as it is expressed in the English common law, "the king never dies." In Dahomey, this fiction assumes the form that no demise of the royal authority has taken place, and the heir reigns in

the name of the old king. Everything that can suggest anarchy, and lend support to the old custom, is carefully set aside. Neither the election of a new ruler, which is always attended with contentions and excitement, nor the death of the old one, is recognized. If anarchy still survives there, where every measure is taken to prevent it, it is only as a shadow of the past.—*Translated for the Popular Science Monthly from Das Ausland.*

THE OIL-SUPPLY OF THE WORLD.*

I.

IT may be, that if the sages of prehistoric China, or the Magi of Chaldea and other ancient civilizations, could return to enlighten our ignorance, they might prove to have possessed far more scientific knowledge than we give them credit for, with some points of practical application which we marvel to think could ever have been forgotten.

Among many such subjects which from time to time call forth our wonder, one of deep interest at the present moment is that old, old subject of pouring oil on rough waves—a subject which (save by a very few practical seamen who happen to have tested the matter for their own preservation) has only within the last three or four years been recognized as a real thing, of most serious importance to all seafaring folk. Hitherto it has been generally deemed merely a poetic metaphor, with no practical foundation. Isolated facts concerning its use were known, as were also allusions to its properties by such sages as Aristotle, Plutarch, Pliny, and, in later days, Erasmus of Rotterdam, Linnæus, or Benjamin Franklin.

When saintly men such as St. Cuthbert or Adamnanus soothed the angry waves by the outpouring of a little oil, this natural result was of course attributed to their own holiness, and the miraculous efficacy of consecrated oil. And even when in A. D. 1776 Lelyveld, a practical Dutchman, published at Amsterdam his "Essay upon the Means of diminishing the Dangers of the Sea *by pouring out Tar-Oil* or other Floating Matter," an essay followed in A. D. 1798 by a more elaborate statement of "Evidence on the Oil Question," published by Otto at Weimar, the interest temporarily awakened soon subsided, and generation after generation of seafaring men have continued wholly to neglect the use of this simple precaution ; and lamentable indeed is it to peruse the appalling record of each winter's wrecks on our own shores, and to note in how many instances life might probably have been saved, had the strong, brave men, so ready to hazard their lives in order to succor others, bethought them of lightening their task by the use of a few gallons of oil.

* Abridged from "Blackwood's Magazine."

And yet, the time is fast approaching when the now rising generation will wonder at the folly of having ever neglected such a means of salvation; for the mass of evidence on this subject which has recently accumulated has now compelled attention from the most skeptical, and the experiments so successfully carried out on the stormy coast of Aberdeenshire, at the harbor of Peterhead, have borne fruit far and near.

Some of the fishers who had witnessed them remembered them to good purpose when trying to enter the harbor at Stonehaven, and warned of their danger by the white-crested waves raging on the bar. They had with them only a little colza-oil and a little paraffine for their lamps (*vegetable* and *mineral* oils)—so little that most men would have deemed it mere folly to cast such upon tempestuous waves. But these men had profited by their lesson. One man stood on either bow, and, just as the boat approached the raging surf, they slowly poured out their offering to the waves, which, as if by magic, ceased to break, and rolled on in harmless green billows, which carried the boat safe into port. I have also just heard from Cornwall that a party of Cornish fishers who chanced to be at Aberdeen at the time of the experiments, and there witnessed the stilling of the waves, returned to their own granite-bound coast with the conviction that they had seen something which hereafter it may be well for them to practice.

Now, thanks to the same large-hearted and energetic Scotchman who planned and brought into practical working the oil-breakwater at Peterhead, the men of Kent can tell with wonder of its application to their own harbor of Folkestone, and are eye-witnesses of how quickly, on a very stormy day, a few gallons of oil have calmed the breaking waves, and made the harbor smooth and safe. The London papers, in reporting on these experiments, have stated the general belief that, by this simple use of oil, entrance and egress to Folkestone Harbor may henceforth be made absolutely secure in the severest storms.

In this relation, therefore, apart from all interests of the non-seagoing population, the question of the world's oil-supply assumes a new and enlarged interest. Here it would appear that Nature herself desires to illustrate the question in a most practical manner, and as the field of her demonstration she selects the Gulf of Mexico. About ten miles to the south of the Sabine River, which forms the boundary between Texas and Louisiana, and about a mile from the shore, there exists a natural phenomenon known to sailors as "The Oil-Spot." In fine weather there is nothing remarkable to attract the attention of a stranger; but when an angry gale from the northeast sweeps the ocean, and great crested waves rise in battle array, this charmed natural harbor reveals itself. No visible boundary divides it from the tempestuous ocean around; but, within a space two miles in length, *the waters remain perfectly calm*, their only change being that they become turbid and red, as though the oil-bearing mud were stirred up

from below. A broad belt of white foam and towering breakers marks where the mighty waves, rolling shoreward in their might, with all the force gathered in an unbroken sweep of seven hundred miles across the Gulf, are suddenly arrested, and sink down, conquered and powerless, so soon as they come within the mysterious influence of this gentlest of rulers.

Unfortunately, this peaceful haven is very shallow; its depth is variously stated at twelve and eighteen feet, so that only vessels of light burden can here take shelter. But to these, blessed, indeed, is the change of passing suddenly from the wild tossing of the outer ocean to the wonderful calm of this strange harbor, where the weary crew may rest as securely as though within an encompassing coral reef. Indeed, the stranger approaching this wall of breakers would naturally assume it to be caused by a dangerous reef, and would, as a matter of course, seek safety by steering away from it.

We believe that no scientific examination of this so-called Oil-Spot has yet been made. Sailors who have here found refuge state that the bottom is of a soft, soapy mud, into which they can easily push a pole to a considerable depth—a mud which, when applied to deck-scrubbing, is found to be exceedingly cleansing.

That the existence of this little haven is due to a submarine oil-spring there can, we think, be little or no doubt, though we have no positive information of discovery of oil-springs on the seaboard of Louisiana or Texas. We know, however, there are many points around the Gulf where petroleum, asphalt, or naphtha in some form, is found in immense quantities, chiefly in the three eastern States of Mexico—Tamaulipas, Vera Cruz, and Tabasco. In the first of these, inexhaustible beds of asphaltum lie on both banks of the river Thamesi. It oozes in an almost pure state through the sedgy borders of the river, and is collected in boats of light draught, which convey it sixty miles down the stream to the port of Tampico.

In the State of Vera Cruz, asphaltum, naphtha, petroleum, stone-coal, and kindred bituminous substances, are found abundantly along the whole coast-range. Six counties are specified, one being especially rich in these deposits, which are sometimes found pure, sometimes mixed with rock-salt and saltpeter. Dr. Hechler, a scientific German traveler, has described the great asphalt-beds near the village of Moloacan. "The salt-mine," as it is there called, is an isolated conical mountain about twelve hundred feet in height, cracked by earthquakes. On its slopes are a number of pits, some of which are cold and still, others seething and bubbling with much noise and a stifling odor. Some of these seething pits eject masses of liquid asphaltum, which the Indians call *chapopote*. The whole adjacent surface consists of asphalt, partly liquid and partly solid, mingled with rock-salt. External heat and subterranean noises tell of the fires still smoldering within the mountain. Dr. Hechler hazards a suggestion that pos-

sibly some day the mountain-crust will subside, and its site be occupied by a bituminous lake, like the Dead Sea of Palestine.

Masses of this *chapopote* are found floating on the rivers and lagoons, or cast up by the waves all along the Gulf coast, when it is collected for sale, and is of excellent quality—clean, hard, and brilliant. Great beds of this substance are found along the upper waters of the Grijalva River, in the State of Tabasco. The deposits of petroleum are specially noted at El Chapopotito, in the county of Ozuluama, in Vera Cruz.

Though no trace of mineral oil has yet been detected in the rocky regions of Central America, its presence has been abundantly proved on the north of the Southern Continent, where, among the most important of recent discoveries, rank the oil-springs on the shore of Lake Maracaibo, in Venezuela, which, together with the great undeveloped coal-mines and other sources of mineral wealth, promise so rich a future to that now waste and desert country.

The chief features of the country between the Cordilleras and the Rio Zulia are the numerous asphalt-mines and petroleum-fountains which abound all around the base of a chain of low hills which lie between the Rio Zulia and Rio Tara. Two other rivers water this country, the Rio Catatumbo and the Rio Sardinarte, which probably accounts for the luxuriance of the cool, dark forest, that contrives to flourish in a region known to the people of Maracaibo as *El Infierno*, by reason of the multitude of fountains and deposits of petroleum and asphalt.

At one point a raised sand-bank is honeycombed with circular holes, from which gush impetuous streams of boiling water and petroleum. Columns of white steam are also ejected with deafening roar. A careful observer estimated that the flow from one of these streams equaled 5,760 gallons per diem. At present all this good petroleum is soon lost again in the earth, and an immense quantity of inflammable gas also escapes and ignites, playing in weird flashes among the dark tree-tops. This earth-born lightning is seen by vessels lying off the bar, and is known as *El farol de Maracaibo*. This group of springs lies near the confluence of the Tara and Sardinarte Rivers, which are navigable for small craft of under fifty tons. But petroleum-fountains, deposits of bitumen, asphalt, and other resinous minerals, lie scattered in all directions; and there is abundant proof of the existence of rich coal-seams, which ere long must certainly create a revolution in Venezuelan commerce.

Near San Timoleo the accumulation of asphalt and petroleum is so extensive as to form a large lake, somewhat resembling the celebrated Pitch Lake on the Isle of Trinidad, where a strange, thick, flexible crust of black bituminous matter is said to float on the surface of a fresh-water lake. But, as no one has yet arrived at even estimating the depth of the crust, it is difficult to see how the existence of the

said lake can be proved. All that meets the eye is a level plain of pitch about three miles in circumference, dotted over with patches of vegetation and bushes, and pools of rain-water, wherein women wash and bleach their linen, while men with pickaxes dig out large fragments of hard, resinous pitch, which are carried off in carts, all on the surface of the so-called lake. Though only about a hundred acres of pitch are thus exposed to view, the deposit crops up at several points five or six miles to the north and to the south, and appears to be only covered by a thin layer of soil or sand. The lake lies about eighty feet above the sea. As the place of the Pitch Lake, in these notes on the world's oil-supply, may not be self-evident, I may venture to remind my readers that the definition of petroleum (*petri oleum*, "rock-oil") is "a native liquid bitumen," which is essentially asphalt dissolved in naphtha. So perhaps we shall some day see the people of Trinidad start their own oil-factories. (The neighboring Isle of Barbadoes also contributes its quota to the world's supply of bituminous asphalt.)

There are numerous petroleum-wells actually within the town of Columbia, and, though the oil is of inferior quality and not abundant, the poor collect it in cloths, which absorb the oil, and are then wrung out into jars, and thus they obtain sufficient to light their houses. So long ago as 1824, samples of this "oil of Columbia" were sent to England, France, and the United States, as a remarkable new discovery; but the secret of distillation had not then been discovered, and kerosene and benzine were unknown products, so this South American oil failed to attract attention. In like manner we learn that in remote ages the citizens of Genoa obtained their oil-supply from the wells on the banks of the Taro. And, in the days of Pliny, Sicilian lamps were fed from the oil-springs of Agrigentum; and long before the Christian era the old Romans knew how to turn to account the oil-wells of Zante. Yet no systematic working of any of these wells seems to have been attempted.

Petroleum in some of its varied forms has long been known to exist in many different parts of Europe. In Galicia, Moldavia, and Roumania, it is found in a semi-solidified form, which led to its being named mineral fat or tallow—as in the so-called "tallow-wells." The ozokerite or earth-wax of Galicia is found in great abundance, and of so pure a quality as quite to take the place of beeswax in the manufacture of candles, etc. A considerable number of the population are employed in mining for it, and also in working the industry in all its branches.

So far back as 1873, the annual return of burning-oil and paraffine was valued at a sum equal to £500,000. This was chiefly obtained from the Boryslaw district.

In 1879 an American oil-refiner from Ohio determined to commence work in Galicia on more scientific principles than any hitherto

attempted. He imported first-class machinery and skilled workmen; but the Poles combined against the interloper, and refused to supply his refinery with crude oil, so for a while he actually was driven to import crude petroleum from America. The people finding that he could not be crushed, desisted from their opposition, and the American refiner now works in peace. He estimates the annual production of Galicia at a hundred thousand barrels, but its quality is generally very inferior to that of Pennsylvania; the sinking of the wells is attended with far greater difficulty, owing to the loose character of the soil, and the singular manner in which the rock strata are found tossed about at every conceivable angle. It is also necessary to bore to a far greater depth than in America. But the chief disadvantage of Galician oil is its liability to explosion, owing to the extreme difficulty of separating the benzine and other explosive elements from the illuminating oil. Altogether Galician oil does not sound very desirable.

In Roumania, in the districts of Bacan, Serata, Buzen, and Dambovitza, petroleum has recently been discovered in such large quantities that there is every prospect of its developing into a very important industry. Prussian Saxony has already established extensive bituminous shale-works, for the supply of shale-oil, in the neighborhood of Weissenfels. Wallachia, Sweden, and Switzerland, also possess deposits of bituminous asphalt, which when systematically worked will, doubtless, be turned to good account.

For a moment let us glance at the principal sources of animal and vegetable oil-supply, ere the fountains of mineral oil were revealed for the use and comfort of the human family.

First and foremost, of course, ranked the fish-oils—the well-known train (or *drain*) oil which drained from the blubber of the great Greenland whale (a large whale sometimes yielding fully thirty tons of blubber—each ton representing nearly two hundred gallons of oil. Though the cachalot, or sperm-whale, could never rival the Greenland whale in the quantity of its contribution, it had at least the advantage of quality and variety, since, besides ordinary blubber, it yields a large amount of sperm-oil, and also of spermaceti. Of the latter valuable product, the head alone often yields ten barrels.

Next among oil-yielding fish come the grampus, or dolphin, the porpoise, the shark, the seal, the cod, the herring, and others.

Of animal fats are butter, tallow, lard, goose-grease, neat's-foot oil (prepared from the feet of oxen, and used by curriers in dressing leather), and mare's grease (imported from Buenos Ayres and Montevideo, where a multitude of horses are annually slaughtered for the sake of their hides, tallow, and bones!). In Russia, especially at Moscow, yolk-of-egg oil is in great repute for making soap and pomatum.

Vegetable oils form a very important item in our supplies, inasmuch as oil-seeds to the value of £5,500,000 are annually imported into Britain for crushing purposes, and our exports of oil are roughly

valued at £1,600,000. The export of seed-oil from London, Hull, and Liverpool, in 1880, was 14,508,000 gallons.

Under the head of seed-oils rank linseed, cotton-seed, and castor-oil. Colza-oil, also, is made from mustard, hemp, radish, rape, turnip, and other seeds. Then we have olive-oil and almond-oil. From India comes poppy-seed oil; from the Black Sea, oil of sunflower-seeds. From Ceylon and the Pacific isles comes cocoanut-oil. From Western Africa the palm-nut oil of the oil-palm, and oil of ground-nuts, for use in fine machinery. From Singapore and China we receive kokum-oil and vegetable tallow. About fourteen thousand tons of croton-oil are annually imported for the use of the wool-dressers of Britain.

Besides these, so familiar to ourselves, almost every country has some specialty in oils. Thus, in Southern Russia, tobacco-oil is largely used; in Italy, oil of grape-stones; in China, oil of tea-seed; in India, oil of nutmegs, of seeds of the gamboge-tree, of custard-apple-seed, of cashew-nut, of cardamom, of neam, of margoza, and many others. Brazil, too, has a large number of oils, both animal and vegetable, peculiar to itself.

In this connection, and bearing in mind Lelyveld's essay on smoothing the waves with tar-oil, we note that Great Britain annually imports five million gallons of wood-tar, and that about an equal quantity is made in the country from coal, at the charcoal-works, the gas-works, and the bone-factories.

To M. du Buisson, a Frenchman, is due the credit of first attempting to distill oil fit for burning from the bituminous shales hitherto deemed worthless. He succeeded in his experiment, but the shales of France were not found to yield oil in paying quantities. An effort was then made to apply the same process to the bituminous shales of Dorsetshire, and "Kimmeridge coal" was found to yield a much larger proportion of oily matter. It was, however, found impossible to overcome the noxious smell of the various products; so that this enterprise did not command large success.

About the year 1847 Sir Lyon Playfair discovered a petroleum-spring at Riddings, in Derbyshire, to which he called the attention of Mr. James Young, a Manchester chemist, who proceeded to distill it, thereby obtaining a clear, thin burning-oil, and also a thick lubricating oil. Certain solid crystals floating in the petroleum suggested the presence of paraffine, and the possibility of obtaining a candle-making substance. This resulted in the manufacture of the first two paraffine-candles, and these were lighted by Dr. Playfair, to illustrate the novel subject at a lecture to the Royal Institution, when he foretold that ere long they would become the common light of the country—a prophecy which was very quickly realized, but not from the Derbyshire springs, as these were soon exhausted.

Mr. Young's attention was next attracted by seeing oil dripping from the roof of a coal-mine, which led to further experiments, with

the result that cannel-coal was found to be essentially oleiferous. The discovery near Bathgate, in Linlithgowshire, of a very rich gas-coal, like the celebrated Boghead coal, led to the establishment of a distillery in its neighborhood, the coal being broken up into fragments like road-metal, and heated to a red-heat in cast-iron retorts. A ton of this coal was found to yield about one hundred and twenty gallons of crude oil. This, being subjected to a second distillation, resolved itself into certain proportions of light oil for burning, thick oil for machinery, a small quantity of naphtha, and a large residuum of paraffine, which, when purified with animal charcoal, is transformed into a substance like beautifully white wax.

Great was the interest excited by this discovery; but difficulties were thrown in the way of Dr. Young's obtaining a patent for his invention, as it was proved that many years previously Reichenbach had tried a similar experiment, and, by distilling one hundred pounds of coal, had obtained two ounces of an oil resembling naphtha. Young, however, carried the day, and his now celebrated patent was granted in 1850.

It was not till six years later that any fresh attempt was made thus to utilize the great beds of bituminous shale which are so extensively found in carboniferous districts, but which had hitherto been totally neglected. These have been found to yield from thirty to fifty gallons of crude oil per ton; and great works for the manufacture of mineral oil have been established at many places in England, Wales, and Scotland.

"Greater Britain" was not slow to adopt the new industry started in the mother-country. In 1865 New South Wales discovered among its hid treasures a shale similar to the Boghead coal of Scotland, but considerably richer in oil, and less sulphurous. A sample was brought to Sydney for distillation, and one ton yielded one hundred and sixty gallons of oil. Thereupon the New South Wales Shale and Oil Company was established, and seems to have developed into a very important industry.

America had taken up the subject earlier. In 1854 the Kerosene-Oil Company and several other companies were started to distill oil from coal, and by 1860 upward of fifty factories for this work had been established in various parts of the States.

Then came the discovery of real mineral-oil wells, which so quickly revolutionized the oil-traffic of the world. Here, as in most other cases, we have evidence of the "nothing-new" theory; for, since King Petroleum has asserted his power, men marvel to find traces of ancient workings, proving that by-gone generations had discovered the native oil—so long ago, that very old trees of several centuries' growth have been found growing in the excavated ground. From some strange cause unknown, these oil-seekers had abandoned their work, and (although mineral oils were known to exist in Asia) their presence in

America had been altogether forgotten, when, in 1826, salt-workers who were engaged in boring brine-shafts in Ohio were amazed to find that they had struck oil as well as brine.

Certainly it was known to the Seneca Indians of Pennsylvania that oil flowed from the rocks at various points in the Alleghany Mountains; and a French traveler has recorded a curious incident which he witnessed in 1750, when the tribe assembled for a religious ceremony, at the junction of a small stream with the Alleghany River. The stream was covered with a thick, oily scum, to which, after a solemn oration, the chief applied a lighted torch. Immediately the flames spread over the surface of the water, amid shouts of the red warriors.

In the same district, at the spot now known as Titusville, was a well on the surface of which oil habitually floated; and the Indians, who had long known its healing properties (now so fully recognized in its refined form as vaseline), were in the habit of collecting it by laying their blankets on the glassy surface of both well and stream, thus absorbing the oil, which they then wrung out and stored for the use of the tribe. So early as 1833 an account was published in "The American Journal of Science," describing how certain persons made a living by skimming this dirty-looking and most unfragrant grease with their boards, and then purified it by heating and straining it through flannel, when it was sold under the name of Seneca-oil, as an excellent specific for healing sores of man and beast, and curing sprains and rheumatism.

In 1853 it occurred to Dr. Brewer that this natural oil might be turned to account for lamps, and the Pennsylvania Rock-Oil Company was formed to develop the idea, with very small result, however, till, in the year 1859, Colonel Drake's attention was attracted by the oil which oozed from fissures of the rock all along the stream now known as Oil Creek. He bethought him that since the rock was apparently saturated with this oil, there must surely be a reservoir which, if it could be found and tapped, would yield a far larger supply than that which was so carefully collected by the company. Little, however, did he dream when he first communicated to them his idea, and was by them empowered to work it on their account, what amazing results would attend his experiment.

He commenced sinking a shaft on the artesian-well principle, and had bored to a depth of six hundred feet, when, to his unspeakable delight, he found that he had indeed reached the main supply, and oil was henceforth pumped up at the rate of from four hundred to one thousand gallons daily. Very soon he was able to rejoice his employers with about two thousand barrels of crude petroleum. New shafts were quickly sunk in every direction, and in the following year five hundred thousand barrels rewarded the lucky borers. This strike proved magical in another sense, for at once the price of crude petroleum fell from twenty-three cents per gallon to twelve cents, and that

of refined oil fell from forty-five to thirty-two cents. Very soon this was further reduced to nine cents for crude oil and nineteen for refined! Already this precious "earth-oil" asserted its privilege of being a special boon to the poor.

Of course, this news spread like wild-fire, and from far and near men came crowding to the wonderful oil-yielding region, and the land was riddled with borings varying from six hundred to sixteen hundred feet in depth, of which it was estimated that not more than one in six yielded profitable returns. Nevertheless, two years after Colonel Drake had sunk his first shaft, the oil-yield had increased to upward of two million barrels, and in the following year it reached three million! As the yield of some wells decreased, new ones were struck in other isolated spots.

Of course, fire is the danger most to be dreaded by all oil-communities. Nowhere, unless in a powder-magazine, does the chance spark carry with it such probability of doing mischief as in this gas-laden atmosphere, where everything seems to be inflammable. Sometimes through grievous negligence, but more often by the action of lightning, a tank containing perhaps three or four thousand barrels of oil is struck, and then all efforts to extinguish the flames are known to be futile—the owners can only stand afar off and watch this magnificent bonfire, which must blaze on till it has utterly consumed all that feeds it. Sometimes the gas escaping from a flowing well ignites while the oil-jet is in full play, and then grand indeed, but most awful, is the spectacle of that genuine "fire-fountain"—a column of living fire tossed far above the dark tree-tops, and falling in a beautiful but scathing rain, with a roar more deafening even than that of its ordinary condition.

Nor do the dread possibilities of fire as connected with the petroleum-trade end here. In all the pages of marine disaster, none are more terrible than those which record how on several occasions (sometimes when in harbor in the midst of crowded shipping) vessels laden with petroleum have taken fire, and their cargo has overspread the sea in a film of inextinguishable floating fire, carrying death and destruction wheresoever it penetrated. This, I think, brings us to the climax of possible horrors in connection with this subject.

The "earth-oil" is found in various parts of North America; but Pennsylvania is said to yield about seven times as much as all the others collectively. Canada has springs of her own to the north of Lake Ontario; but the great petroleum-region of the States lies partly in New York, but chiefly in Pennsylvania near the shores of Lake Erie. The oil-bearing sandstone underlies a tract of heavily timbered hill-country watered by the Alleghany River. Here the principal oil-springs have been struck in isolated patches, dotting a belt of territory which is roughly estimated at about one hundred and fifty miles in length by about thirty in maximum breadth, covering an area of less than

200,000 acres. Ohio and West Virginia also contribute something to the general oil-supply.

To whatever cause the formation of petroleum is due (and it is generally attributed to the decomposition under enormous pressure of vast deposits of animal and vegetable matter), it is now ascertained that it exists in rocks of nearly all geological ages. Upper and Lower Devonian, Silurian, and Tertiary, have all been proved to be oleiferous. One thing worthy of note is, that the springs are generally found near the base of great hills. We have already seen that those of Venezuela lie among the spurs of the Cordilleras. Those of Pennsylvania lie chiefly near the Alleghanies, and the great oil-region of the Caspian is overshadowed by the Caucasus.

In the year 1876 (seventeen years after Colonel Drake had bored his first well) it was estimated that 20,000 wells had been sunk in Pennsylvania and West Virginia at a cost of $190,000,000, the oil produced being valued at $300,000,000 at the wells—cost of carriage to the seaboard adding one fourth to the value of an oil-cargo. In 1879 the production of oil in the United States was estimated at about 15,000,000 barrels, equal to 600,000,000 gallons. In 1880 upward of 400,000,000 gallons, valued at $46,000,000, were exported from the States, irrespective of the enormous home consumption.

Very remarkable is the organization whereby an elaborate system of iron pipes connects all the wells in the most remote districts of Petrolea with enormous tanks, wherein the oil from many wells is stored, and is thence conveyed by main pipes to the nearest railway-station, where it runs into another series of great reservoirs, thence to be transferred to the locomotive tanks or oil-wagons. These are cylinders resembling great steamboat funnels laid lengthwise on the wagon. From the center of each cylinder rises a large iron cupola, constructed to allow for the expansion of the oil should it become heated. Such wagon-trains are about as dirty and greasy looking concerns as can well be imagined.

In many cases their services are dispensed with, and the main pipes —which have a diameter of from four to six inches—are carried direct to the great refineries. One of these at Cleveland is one hundred and seven miles distant from the wells which feed it; another at Buffalo is distant seventy-eight miles; and that at Pittsburg is thirty-eight miles from its source of supply. Two great main pumps are led three hundred miles to Bayonne on the seaboard of New York Bay, and there deliver their cargo ready for shipping. Pumping-engines working at intervals of twenty-five miles give an impetus to the flow of these oil-streams.

This pipe business is all in the hands of two great companies; and some idea may be formed of the vast scale on which they work, from the fact that the principal company—distinguished as "The United Pipe Lines Company"—owns three thousand miles of pipes, and

provides in its five hundred great iron tanks storage for upward of 30,000,000 barrels! The company receive all the oil yielded by the wells of certain districts, and account to the owners of each for the amount received.

The oil thus obtained is not all alike in quality. There are a few wells at Mecca in Ohio, some in Illinois, and others near Franklin in Pennsylvania, where it is of extraordinary thickness, and can be used as grease without further preparation. It fetches about five times the price of ordinary crude petroleum, and at the present moment sells at £4 per barrel. At Mecca this lubricating oil is found in an area fifteen miles in length by five in width. It is estimated that 500,000 barrels have already been taken out, by pumping wells at an average of forty feet in depth.

Passing north across Lake Erie to the "Dominion," we find four distinct oil-bearing areas. They lie in Tilsonburg, Enniskillen, Mosa, and Oxford townships. As in the States, so in Canada, the oil-region has been suggestively named Petrolea—a name, however, which applies eepecially to this principal city.

It is just about twenty years since Mr. Murray, geological surveyor, in riding through the dense untrodden forests of oak and hickory, observed here and there beds of bituminous matter, and on closer examination he became convinced that these were deposits where oil-springs had overflowed and evaporated. At a place now known as Thamesville (the counterpart of the Titusville of Pennsylvania) he perceived oil floating on a stream, and found that there, too, the people were in the habit of gathering up this scum in flannel, and using it as ointment for wounds on horses.

He called official attention to the subject, and soon the silence of the forests was a thing of the past, and the district was overrun by crowds of busy men.

Now oil cities "spring up" with mushroom speed, wherever productive springs are struck in new districts. With oil, as with all else in the States and the Dominion, there is a constant movement toward the northwest; and every one, who finds his oil-supply failing, as a matter of course moves to the northwest, taking with him his pump and derrick, and all the casing of the well, and sets up his drilling apparatus wherever the ground appears most promising.

The yield of oil is not to be compared with that of the Pennsylvania springs, and two years ago it was estimated that the sixteen hundred wells then in active operation did not collectively yield on an average more than 2,400 barrels per diem. The richest well at present is "The Lawyer," near Marthaville, which has an average flow of eighty barrels a day; but, on the other hand, many only yield one barrel. The oil here is generally a greenish-black fluid of the consistency of sirup, and is mixed with much water and some gas.

[*To be continued.*]

SKETCH OF PROFESSOR JAMES HALL.

THE name of Professor James Hall is inseparably associated with the growth of American geology, the classification of the palæozoic strata of the continent, and the systematization of their paleontology. Connected with the New York State Geological Survey since 1837, he has been for about forty years, as chief of the paleontological department, engaged in the study of fossil remains. His words are now referred to in illustration of, and his name is cited as authority on, questions connected with the older geological formations of the continent, by the geologists of the world more frequently than those, probably, of any other American in the same field.

JAMES HALL was born, of English parents, in Hingham, Massachusetts, on the 12th of September, 1811. He studied natural history, under the direction of Amos Eaton, at the Rensselaer Polytechnic Institute in Troy, New York, where he afterward became Professor of Geology. Professor Eaton had already, by his lectures before the members of the State Legislature and other audiences, and by his instrumentality in the organization of the Troy Lyceum of Natural History and in the formation of its geological collection, contributed to awaken an interest in the study of the natural history and geology of the State. He had superintended an agricultural and geological survey of Rensselaer and Albany Counties, and had made a survey of the district adjoining the Erie Canal, and published a report upon it. The subject of instituting a complete geological survey of the State was presented before the Legislature in 1834, and the act making provision for the work was passed in 1836. In the organization of the survey the State was divided into four districts, of which Mr. Hall was appointed assistant in the second district, under Professor Ebenezer Emmons, of Williams College. The district included the counties of Warren, Essex, Clinton, Franklin, Hamilton, and St. Lawrence, and afterward Jefferson. At the end of the year, on the appointment of Mr. Conrad, of the third district, to the department of paleontology, and the transfer of Mr. Vanuxen, of the fourth district, to the position he vacated, Mr. Hall was made geologist of the third district, including the counties of Montgomery, Herkimer, Oneida, Lewis, Oswego, Madison, Onondaga, Cayuga, Wayne, Ontario, Monroe, Orleans, and Livingston. He published annual reports of his work regularly from 1838 to 1841, and concluded the series with a final report in 1843, which forms one of the series of works on the natural history of the State published by the Legislature. In this volume he gave a full description of the order and succession of the strata, their mineralogical and lithological characters, and the organic remains contained in them. Concerning the form in which the volumes of the reports are published, Professor Hall has related an incident that affords a curious

illustration of American official spread-eagleism. The incumbents of the several departments of the survey wished to publish their works in octavo, so that the results might appear in convenient form, and become hand-books for students of science. The plan was overruled by Governor Seward and his advisers, "who considered it due to the dignity and importance of the State of New York that the volumes should be published in quarto form, especially as they were to be presented to other States and foreign governments as emblematic of the greatness of the State." The survey was reorganized between 1842 and 1844. A department of agriculture was added, and the paleontological department—Mr. Conrad having resigned without making a report—was assigned to Professor Hall, who began his work in 1844, "almost without a collection of fossils of any kind, without a library for reference, without artists, or any of the appliances or resources considered necessary in scientific investigation. It became necessary to create the department from the beginning." No appropriations of money were made by the State for the collection of fossils till 1856, when provision was made for eight years, and the whole burden of labor and expense was till then thrown upon Professor Hall. He was assisted in these arduous labors by his wife, who drew the figures of a large number of the fossils.

Five volumes of the "Paleontology" have been published, two of which were divided into two parts, making seven bound volumes. As analyzed by Dr. T. Sterry Hunt, the first volume, of 338 pages and one hundred plates, contains descriptions of all the organic remains, both of animals and plants, beginning with the lowest member of the New York system and ascending to the Champlain division, which terminates in the Hudson River group, corresponding to the Cambrian of Sedgwick, or the Cambrian and Lower Silurian of Murchison. The second volume, of 362 pages and more than a hundred plates, continues the system up to the base of the Onondaga or Salina formation. The third volume, of 533 pages, with 128 plates, includes all the fossil remains of the water-limes, the Lower Helderberg, and Oriskany divisions, except the corals and bryozoa. The fourth volume includes the brachiopoda of the Upper Helderberg, Hamilton, Portage, and Chemung divisions, which together constitute the Erian or Devonian. The fifth volume contains the lamellibranchiates of the divisions just named, together with a review of all the lamellibranchiate forms of the lower formations. Two other volumes are to include the gasteropodæ, cephalopodæ, crustaceæ, crinoideæ, bryozoæ, and corals of the Erian. Professor Hall has prepared, also, for the "Paleontology," a complete revision of the brachiopods of North America, with about fifty plates, in aid of which he has extended his researches to the Rocky Mountains, tracing the great divisions of the New York series over the intervening region; and the identifications made by him have served as the basis of all our knowledge of the geology of the Mississippi Basin.

Professor Hall himself says of the *rationale* of the system of nomenclature under which the New York surveys were conducted, and which has served as the basis of the Western surveys: "Since there was no possibility of identifying the individual rocks and groups of strata with those of Europe, as described, the New York geologists were compelled to give names to the different members of the series; and since the sandstones, limestones, slates, and shales are so similar in different and successive groups, it was impossible to give descriptive names which would discriminate the one from the other. Therefore, local names were proposed and adopted; as, for example, Potsdam sandstone, Trenton limestone, Niagara limestone, and Niagara shale (the two latter, with subordinate beds, making up the Niagara group), the Medina sandstone, the Onondaga salt group, the Hamilton, Portage, and Chemung groups, thus giving typical localities of the rock instead of descriptive names. This method or system of nomenclature leaves no possibility of mistake or confusion which might arise from a different appreciation of descriptive terms. The typical locality always remains for study, comparison, and reference, and there need be no difference of opinion or discussion as to what was intended by the use of any one of the terms. The progress of geological science in the country is greatly indebted to this system of nomenclature, and to the absolute working out of the succession of the groups, and the members of the same, to which it has been applied." The system was adopted by a vote of the Geological Board.

The geologists of the survey were accustomed to meet once a year in the Capitol of the State, to compare notes. "The comparison of observations and interchange of views led to the opening of correspondence, by a formal resolution of the New York Board, with other geologists, especially with those engaged in State surveys, of which several were then in progress. This correspondence led to an agreement for a meeting of geologists in Philadelphia in the spring of 1840, and this assemblage, of less than a score of persons, led to the organization of the Association of American Geologists, which, at a later period, on the occasion of its third meeting, added the term Naturalists; and, finally, by expanding its title, it became the American Association for the Advancement of Science." Professor Hall was president of this association, under its present title, at its Albany meeting in 1856.

The general results of Professor Hall's comparative studies in the West are given in the third volume of the "Paleontology," and more fully in the first volume of the "Report on the Geology of Iowa," where he was engaged in the survey, with Whitney and Worthen. To this survey he contributed a memoir on the paleontology of the State, as he did to the survey of Wisconsin; and some of the fruits of his paleontological labors may be found embodied in the geological reports of several other States. He declined to take the direction of the

paleontological department of the survey of Canada, under Sir William Logan, but undertook the study of the graptolites of the Quebec group, and published a monograph on them, which was afterward republished, with additions, in the "Twentieth Report of the New York State Cabinet of Natural History." The list of his other contributions to American geology includes articles in the reports of the "State Cabinet and State Museum"; "Descriptions of Organic Remains," given in the Government reports of various Western surveys, including the reports of Fremont, Stansbury, and the boundary survey of the United States and Mexico; and numerous contributions to the "American Journal of Science," and to various scientific societies at home and abroad. He is a foreign member of the Geological Society of London, and received the Wollaston medal from it in 1858; and is a corresponding member of the Institute of France.

M. Ch. Barrois, reviewing in the "Revue Scientifique" the latest published volume of Professor Hall's "Paleontology," says that, like all the other publications of the author, it "brings an ample harvest of new and important facts. It would form the base and the foundation of the study of the palæozoic bivalves, if it did not have to share that honor with the work recently published by our regretted compatriot Barrande, on the 'Acephalæ of the Silurian of Bohemia.' Never will the names be separated of these two superior men, who have devoted themselves during this century with an equal activity to the study of the palæozoic faunas. Born in countries distant from each other, in environments still more widely separated in modes of thought, Barrande and James Hall came to fill the same part in the history of science. The same love of research and of the truth animated them; the same indomitable energy constantly encouraged and sustained them; and, with all the work that has been accomplished by numbers of other specialists, every one will recognize that these two men have competently described the fauna of the transition-beds. They have done more in that direction than all the rest of their generation."

Professor Hall devoted much attention to the study of crystalline as well as of fossiliferous stratified rocks, and was, according to Dr. Hunt, the first to point out the persistence and significance of mineralogical character as a guide to their classification, in the manner which has since been developed and extended by the latter geologist. Among his other most important contributions to geological science is his suggestion of a rational theory of mountains, in regarding them as the products of erosion, aided by the upheaval and contortion of strata as an incidental, not a chief factor.

The magnificent collection of fossils accumulated by Professor Hall during the course of his geological work has been transferred to the American Museum of Natural History, and now forms a part of the cabinet in the New York Central Park.

EDITOR'S TABLE.

THE AMERICAN ASSOCIATION AT PHILADELPHIA.

THE recent meeting of the American Scientific Association at Philadelphia was an eminently successful one. It was the largest ever held, the number of papers read was greater, and their merit above the past average. The presidential address by Professor Young, which we reprint, was a production of unusual ability. He chose the theme upon which he was best qualified to speak, the present state of astronomical science, with reference to its imperfectly solved problems, and the researches to which attention must next be given.

The great drawback to the enjoyment of the meeting was the intolerable heat, which was the more aggravating as there was so much to see, and so much laid out to do; but the Philadelphians, by their generous hospitality and their liberal arrangements for the pleasure and entertainment of visitors, did everything possible to mitigate the calamity of the weather.

The project of a permanent international scientific association, to which we have before called attention, was taken up and favorably received, although in the opinion of many the time has not yet come when such a plan can be vigorously carried out. It is reported that the project "has now a more assured existence" inasmuch as the philanthropist, Mrs. Elizabeth Thompson, has contributed $5,000 to it and will give $5,000 more next year, on the condition that $10,000 are furnished from other sources. This lady also donated $1,000 to the American Association to promote researches in light and heat.

The coming of the British Association in full force to Montreal to hold a meeting, to be immediately followed by the session of the American Association in Philadelphia in which many British scientists took part, has naturally raised various questions of comparison between the policy and working of the two bodies. We give some of the points of comparison and contrast.

The Canadian meeting was considerably the larger: 1,773 members were registered, of whom about one half crossed the ocean. This is below the average of the past ten years by about a hundred members. The number of members registered at Philadelphia was 1,261, or about five hundred less than at the Montreal meeting. Of these, 303 were foreign visitors.

Fewer papers were read at the American Association than at the British, but more in proportion to the membership, 304 being reported at Philadelphia, and 327 at Montreal. But some forty, or one eighth of the entire number, were contributed by American gentlemen attending the Canada meeting. The character of the work at both meetings is generally admitted to be above the average. Of the five papers recommended by the British Association to be published in full, two were from the States; one by Professor Gray, and one by Professor Thurston.

Both Associations adopt the plan of appointing special committees to investigate and report upon designated subjects; but the British Association carries it out much more thoroughly than the American. While the reports at the Philadelphia meeting were so meager that "it can be hardly said there were any," on the other hand, "in addition to the regular papers, there were in the various sections of the British Association more than fifty reports presented, coming from committees ap-

pointed at previous meetings." This is at least partly accounted for by the fact that the British Association makes grants of money to its committees to remunerate for services, no less than $7,500 being thus allowed at the Montreal meeting, while our own Association makes no such allowances.

Upon bringing English and American scientific work into the closer comparison which this new experience allows, the superiority, it must be confessed, belongs to the older and larger body. A writer in "Science," after contrasting various features of the two organizations, justly remarks: "On the whole, it will be admitted that the British Association does its work upon a higher plane than that occupied by the American. Its sectional work shows more that is really new and of lasting value, and less that is trifling; although there has been a steady and healthful improvement in the character of the American Association during several years past. It may be well to remark here that there are at least a few of the ablest and best men in American science who have continued to exhibit no interest in the American Association; and that, if the Association is not precisely what they believe it ought to be, the fault lies at their own doors. No others should or could be so influential in shaping its course and molding its character."

HARRISON, COMTE, AND SPENCER.

UPWARD of twenty years ago, when Mr. Herbert Spencer first began to publish the system of thought upon which he has since been occupied, he was charged with being a disciple of Comte, and indebted to him for his cardinal ideas. The reply made by Mr. Spencer at the time was generally held to be so effectual that but little more was heard of the matter. But some of the more ardent followers of Comte refused to be convinced, and among them is Mr. Frederic Harrison, who has now revived the accusation, and stoutly maintains that, if not directly, then indirectly, Spencer owes his main and most characteristic conceptions to Comte.

It has been well understood that Mr. Frederic Harrison is the leading English representative of the Positive philosophy, though, like Mill, he has been credited with a good deal of independence and reservation in the acceptance of the Positivist system. But his address on September 5th before the members of the Positivist Society at Newton Hall, in London, where he preaches, shows a servility of discipleship for which we were quite unprepared. The subject of the discourse was "The Memory of Auguste Comte and his True Work," the occasion being the anniversary of the death of that philosopher. It was, of course, to be expected that Mr. Harrison would not let such an opportunity pass without speaking in high terms of the genius of Comte and the importance of his labors; but the performance is quite startling from its lurid eulogy and the wild extravagance of its claims in regard to Comte's character and mission. He credits him substantially with all the greatest steps of advance in science, philosophy, and religion that have been made in the present century. Comte's classification of the sciences is pronounced to be final. Though a phrenologist, and openly repudiating modern psychology, Mr. Harrison insists that Comte has made the most important step of the century in psychology. The idea that law rules in the moral and social as well as in the physical sphere belongs to Comte. He instituted the science of sociology, and constituted it in all its material parts. And, among his other accomplishments, this wonderful Frenchman challenges the admiration and gratitude of the world as the founder of a new religion.

These undiscriminating and inordi-

nate claims leave little room, of course, for the recognition of the merits of other men; all who came since are but followers and imitators of Comte. It was supposed that Mr. Spencer had done some important original work in philosophy, psychology, and sociology, but Mr. Frederic Harrison says he has given the world nothing "but a very unsuccessful attempt to re-edit Comte's work on a plan of his own."

Such a charge as this could not assuredly be suffered to pass; and it is well that it was thus sweepingly made while Mr. Spencer is living and able to deal with it. The publication of Harrison's address opened a controversy at once in the leading London newspapers. We have room for only a part of it, and we select the most important part. We reprint two letters by Mr. Spencer, which are of interest as throwing light upon the true origin of his system. It will not be denied that Mr. Spencer knows more about it than anybody else; and when attacked by this imputation of wholesale plagiarism, the alternative of incompetence to judge where his leading conceptions came from, it is desirable to know what he has to say, both as a question of the history of thought and as a matter of justice to himself. We have a vast apparatus of legislatures and courts to secure to men their material possessions; but, when it comes to property in ideas, nothing remains for thinkers but to lose it or to defend it themselves.

IS THE CONTRAST VALID?

President Porter, of Yale, has lately made answer, in the "Princeton Review," to the argument of President Eliot, of Harvard, in the "Century," entitled "What is a Liberal Education?" At the close of his paper, Dr. Porter refers to the Appendix to the third edition of "A College Fetich," in which Mr. Adams has included the chief portion of the paper of Professor James on "The Classical Question in Germany," and some other matter from "The Popular Science Monthly."

We are glad to observe that Dr. Porter admits the essential justice of Professor James's case. The "Berlin Report" had been translated and widely circulated to show that, by long and extensive German experience in the trial of two school systems, it was settled that classical education is superior to scientific education; and that this was admitted even by the most eminent scientific men. Professor James proved that the "Report" settles no such question, and Dr. Porter so far acknowledges this as to say, "It may certainly be conceded to the critic that the 'practical trial' of the two systems of study —the classical and the non- or less classical—was not in all respects fair or decisive." If Dr. Porter had said it was not in *any* respect fair or decisive, we believe he would have been still nearer the truth.

But we are just now more concerned with another point of his statement in relation to the validity of the contrast, for important educational purposes, between the study of words and the study of things. Dr. Porter refers to this matter as follows:

> The long extracts from Professor E. L. Youmans, taken from "The Popular Science Monthly," are significant as urging the point made by President Eliot, that classical is essentially inferior to scientific culture because "it trains the verbal memory and the reason so far as it is exercised in transposing thought from one form of expression to another, . . . while the new method cultivates the powers of observation and the faculty of reasoning upon the objects of experience so as to educate the judgment upon the problems of life. . . . The problems of life, as we understand them, are to a very large extent those which concern human relations, and these are quite as important as those which are commonly called facts or phenomena. To a large extent they are not material relations, and are not subjects of sensible experiment or verification. The facts and the reasoning must also be stated in language clearly, forcibly, and convincingly, in order to convince the

reason and affect the conduct. To interpret and employ language, even with those who think themselves employed about facts, is consequently one of the chief occupations of all those who have power with their fellowmen, whether their sphere of thought is material or spiritual 'things.' The pretended contrast between thought and words is not valid, especially when used for so sweeping an induction as that made by Professors Cooke and Youmans or President Eliot."

The contrast between words and things is certainly not a pretense but a reality; and we are unable to see how the validity of the induction in this case is in any way dependent upon the sweep of its application. It is claimed by nobody in this controversy that words are unimportant or that language-studies are not of great value; but it is maintained that the things represented are more important than their signs, and Nature-studies of higher value than lingual studies, and the whole issue turns upon the recognition of this fact. Historically, this contrast has been proved to be profound and momentous. In the pre-scientific ages, words were not only put in the place of things, but confounded with them so as to vitiate whole systems of thought as shown in the history of Greek speculation and the scholasticism of the middle ages. The investigation of truth was made to consist in mere verbal manipulations. The Baconian reform in philosophy consisted in demanding that the human mind shall no longer occupy itself in the verbal sphere, but shall break through the barriers of words and study the things they represent. The inductive philosophy began with facts—the observation and investigation of things—and was a new method which has revolutionized knowledge, created the modern sciences, and revealed the order of Nature. It is contrasted with verbal and literary studies, which accept common notions—the loose, vague, crude ideas of ordinary experience—and can not advance and perfect knowledge because it refuses to make facts first and to exercise the mind in their close and careful study. Is a contrast so broad as this, between a fruitless method which kept the mind stationary for centuries and a method so fruitful as to give origin to a vast body of accurate and productive truth, to be regarded as a pretense when it is claimed to be fundamental in education? The verbal system is historic, traditional, popular, and all-prevalent in our systems of mental cultivation. It is proposed by the reformers not to destroy it, but to reduce its exaggerated proportions, and give greater prominence to the systematic study of actual things. The demand is that there shall be a new discipline in education, begun early and pursued thoroughly, by the mastery of given branches of science at first hand. The contrast between words and things must be at any rate held valid for the accomplishment of this reasonable object. That this claim is a moderate and sober one, and has long been firmly held by educators of the highest character, might be shown by quotations from many authorities; Dr. William Whewell thus remarks upon it:

Of the mode in which this culture of the inductive habit of mind, or at least appreciation of the method and its results, is to be promoted—if I might presume to give an opinion—I should say that one obvious mode of effecting this discipline of the mind in induction is, the exact and solid study of some portion of inductive knowledge. I do not mean the mechanical sciences alone, physical astronomy and the like, though these undoubtedly have a prerogative value as the instruments of such a culture; but the like effect will be promoted by the exact and solid study of any portion of the circle of natural sciences; botany, comparative anatomy, geology, chemistry, for instance. But I say the *exact* and *solid* knowledge; not a mere verbal knowledge, but a knowledge which is real in its character, though it may be elementary and limited in its extent. The knowledge of which I speak must be a knowledge of things, and not merely of names of things; an acquaintance with the operations and productions of Nature, as they appear to the eye, not merely an acquaintance with what has

been said about them; a knowledge of the laws of Nature seen in special experiments and observations, before they are conceived in general terms; a knowledge of the types of natural forms, gathered from individual cases already made familiar. By such study of one or more departments of inductive knowledge, the mind may escape from the thralldom and illusion which reign in the world of mere words.

LITERARY NOTICES.

A NATURALIST'S RAMBLES ABOUT HOME. By CHARLES C. ABBOTT. New York: D. Appleton & Co. Pp. 485. Price, $1.50.

THERE is no denying that natural history is one of the most fascinating of subjects, and now and then there appears a book written by some enthusiastic lover of nature, who has entered into communion with the inferior animate creatures, and writes a living book so pleasing and attractive that it is sought by readers with the avidity of a romance. Such works are never compilations, never scientific treatises, in the usual sense, but always original in observation, full of instruction, life-like and agreeable in description, and abounding in sympathetic interest with the habits, peculiarities, and curious lives of that portion of the animal kingdom which is taken up.

Mr. Abbott's book belongs to this class. Its author is a working naturalist who has made animal life a systematic and scientific study, of course with the aid of books, museums, and the usual helps, but he has always been fond of making the acquaintance of all the animals within reach, watching their ways, noting their characteristics, clearing up obscurities in their history, and finding out everything he could of interest concerning them. He has been an out-of-door student, at home with all sorts of mammals, birds, reptiles, and fishes that he could find in his neighborhood excursions, and the present book is a charming record of his varied observations, investigations, experiences, and adventures in his natural history excursions about home for many years.

We have often thought of that wealth of the farmer owning one or two hundred acres of land, which he never inventories when making up a statement of his property. It is wealth which he can not sell, but does not have to buy, and he can only know of its existence or appreciate its magnitude in proportion to his intelligence regarding natural things. The soil of his hundred acres is a chemical laboratory in which he operates upon hundreds of thousands of tons of materials to carry on the most exquisite and multifarious chemical changes. Mineralogy and geology explain the depths of his estate. He may be said to own the atmosphere as far up as it extends above his grounds, with its millions of tons of gases, and if he is familiar with Sir William Thomson's paper on "The Energy of a Cubic Mile of Sunlight," he can understand the enormous amount of solar power which is necessary to drive the organic operations of his farm, and of which he may regard himself as the proprietor. Then there is a little world of vegetable life, of which he is the intellectual owner, if he knows something of botany, while his streams and ponds and earth abound with animal forms, besides the endless insect-life, the animals of field and forest, and the birds of the air, which are in a high sense his if he has enough of zoölogy to understand them. The lesson of the situation is, that there is an inexhaustible wealth and world of wonders about home to the mind so cultivated that it can discover and appreciate them.

Mr. Abbott has limited the scope of his natural history observations to his home environment, and he accordingly offers us "A Word at the Start, in Lieu of Preface," in which he describes his location and gives some clews to its interest for natural history purposes. He lives in "the Jerseys," on Crosswicks Creek, a navigable stream that enters the Delaware River at Bordentown. His ancestor came from Nottingham two hundred years ago, and he now lives in a house built by his great-grandfather on the edge of a high terrace, and surrounded by old oaks, beeches, and locusts, under which the author declares that he chiefly lives. There is nothing romantic in the neighborhood, but it has long been a center of special interest to students of natural history. It has been much visited by botanists and zoölogists—Bertram, the poet and naturalist; Conrad the elder, botanist and mineralogist; Conrad the geologist, his son; and Rafinesque, Say, Le Seure, Bona-

parte, Wilson, and other celebrities, visited the location; and the names of some, cut by themselves in the bark of one of the old beeches that guards a famous spring, are still to be deciphered. Such is the neighborhood which Mr. Abbott has explored for its natural history resources, and the results of which are described in these "Rambles about Home." His book is most entertaining. It is written in a simple, unaffected, and entirely untechnical style, and the reader becomes at once interested wherever he dips into the book. Mr. Abbott writes constantly of what he has himself seen, and he has been a painstaking and indefatigable searcher of all kinds of curious and interesting things in the life-history of the beasts, birds, fishes, and reptiles which belong to his immediate region. It is unnecessary to give illustrations here of his way of working, as we have already quoted from his teeming pages in the August "Monthly"; but we cordially recommend the volume to those in search of useful and agreeable reading as one of the pleasantest books of the season.

THE DISCOVERIES OF AMERICA TO THE YEAR 1525. By ARTHUR JAMES WEISE. New York: G. P. Putnam's Sons. Pp. 380, with Maps. Price, $4.50.

THIS book bears the marks of industrious research in fields that have not yet been overworked, and which offer irresistible allurements to the historical inquirer. Starting with the assertion that "America in the early ages was one of the inhabited parts of the earth," the author accepts as historical the story of Atlantis, which is said by Plato to have been told by the Egyptian priests to Solon, and repeats it, while he finds confirmation of a part, at least, of its incidents in the biblical account of the first men. He discredits the relations of the discoveries of America by the Northmen as resting "more upon conjecture than evidence." Then, reviewing briefly the stories of the voyage of the Welsh Madoc and of the discoveries of the Zeni brothers, and the travels of Marco Polo and Sir John de Mandeville, he finds himself at last upon safer ground in treating the history of the voyages of the early Portuguese navigators, and Columbus, and of those who followed them. The whole is enriched with copious citations from the mass of literature on the subject, ancient and modern, much of which is rare. On this point the author remarks that the writing of his work "required the personal examination of many old and rare books, manuscripts, and maps, besides the perusal of a large number of recent papers and publications relating to its subject. The task further demanded a careful review and comparison of the various statements of historical writers concerning the voyages of the persons whom they believed to have been the discoverers of certain parts of America. . . . It seemed to me that some of the information contained in the different works which I had examined should be presented in the language of the writers, or in faithful translations, so that the intended significance of the information could be perceived by the reader." Thus, by its matter, and the way in which it is presented, the work is one of great value and unusual interest.

SAMUEL ADAMS, THE MAN OF THE TOWN-MEETING. By JAMES K. HOSMER. Baltimore: N. Murray. Pp. 60. Price, 35 cents.

THIS sketch, which is based on studies for a new life of Samuel Adams, is one of the "Johns Hopkins University Studies" in Historical and Political Science. Its aim is, first, to present a life-like picture of the New England town-meeting in its purest state as illustrated in the meetings of Boston town in colonial times; and, second, to exhibit Samuel Adams as the conspicuous leader of the town-meeting, and as one of the ablest as well as one of the purest managers of men in our history. The tracing of Adams's work in the under-currents of politics is very clear; and from it he appears as a principal though not always an open director of the movements, in the South as well as in the North, that resulted in the Revolution.

ON THE NATURE OF LIGHT. By GEORGE G. STOKES, M. A., F. R. S., etc. London: Macmillan & Co. Pp. 133. Price, 75 cents.

PROFESSOR STOKES, having been appointed to deliver three annual courses of lectures, on the endowment of John Burnett, of Aberdeen, chose "Light" as his general subject, and devoted the four lectures of the first course to a discussion of the nature of

light. These discourses, which constitute the present volume, were delivered in November, 1883. In the first, the emission and the undulation theories of light are stated, and the insufficiency of the former is shown. Explanations of the phenomena of interference and diffraction by means of the undulation theory follow, and, in the third and fourth lectures, double refraction, polarization, and the interference of polarized light are considered.

CHEMISTRY: GENERAL, MEDICAL, AND PHARMACEUTICAL, including the Chemistry of the United States Pharmacopœia. By JOHN ATTFIELD, F. R. S. Tenth edition, specially revised by the author for America. Philadelphia: Henry C. Lea's Son & Co. Pp. 727.

THIS compact volume is, first of all, a text-book of general chemistry, in which the substances and processes used in medical and pharmaceutical chemistry have been employed in illustrating the principles of the science. "From other chemical text-books," says the author in his preface, "it differs in three particulars: first, in the exclusion of matter relating to compounds, which at present are only of interest to the scientific chemist; secondly, in containing more or less of the chemistry of every substance recognized officially or in general practice as a remedial agent; thirdly, in the paragraphs being so cast that the volume may be used as a guide in studying the science experimentally." The book contains also directions and tables for qualitative and quantitative analyses, and in these departments, likewise, special prominence is given to substances used as drugs. Naturally, organic compounds receive more attention than in the ordinary text-book on general chemistry, and a large amount of information, valuable to the physician and the pharmacist, is distributed through the volume.

ELECTRICITY, MAGNETISM, AND ELECTRIC TELEGRAPHY. By THOMAS D. LOCKWOOD. New York: D. Van Nostrand. Pp. 377. Price, $2.50.

TELEGRAPH and telephone operators, line-men, and others connected in similar capacities with the applications of electricity, have generally had scanty opportunities for education, and seldom possess a sufficient understanding of electrical science to enable them to attain important and lucrative positions. It is especially for this class that the present book is written, though it is equally available for the general reader who wishes to understand the construction and operation of the electrical appliances which he sees in use. The text is arranged in the form of question and answer, the answers varying from a few lines to a couple of pages in length, and is illustrated with 152 cuts. Frictional and voltaic electricity, thermo-electricity, and magnetism, are taken up in successive chapters, questions about dynamo-electric machines are then answered, and two chapters are devoted to methods of electrical measurements, and to the terms and units used. The next eight chapters are devoted to telegraphy, beginning with the principles as exemplified in different systems, and including such subjects as line-construction and the adjustment and care of telegraph-instruments. Electric lighting, electro-metallurgy, electric bells, electro-therapeutics, and the telephone, are dealt with in single chapters, and a number of minor applications receive brief mention. Tables showing the weight and electrical resistance of various qualities of wire and other tables are appended.

THE PRINCIPLES OF VENTILATION AND HEATING, AND THEIR PRACTICAL APPLICATION. By JOHN S. BILLINGS, M. D., LL. D., Surgeon U. S. Army. New York: "The Sanitary Engineer." Pp. 214. Price, $3.

THIS book contains the substance of a series of articles originally published in "The Sanitary Engineer," with some new matter. It is intended to present the general principles which should guide a person in judging of various systems of, and appliances for, ventilation. Dr. Billings insists on the inseparable connection between ventilation and heating, and lays down as his first axiom, which applies especially to the large cities in our Northern States, that "in this climate it is impossible to have at the same time good ventilation, sufficient heating, and cheapness." After some preliminary considerations of heat and gases, the author takes up methods of heating, patent systems of ventilation and heating, means for removing dust and for supply-

ing moisture, and chimneys. Chapters are devoted to the ventilation of halls of audience, theatres, schools, and hospitals, and to ventilation by aspiration. The volume is illustrated by seventy-two plates and diagrams.

NATURAL LAW IN THE SPIRITUAL WORLD. By HENRY DRUMMOND, F. R. S. E., F. G. S. New York: James Pott & Co. Pp. 414. Price, $1.50.

THIS interesting book is directed to the problem of the relations of religion and science, and presents a new view from an advanced stand-point, which many regard as helpful and healthful in its influence. It is not to be denied that the author's purpose is an exalted one, nor that he deals with his subject in an independent and original way, and with skill and power. His object is the essential harmony of science and religion, and his method is to show that the system of law which is established in the natural world holds equally true in the spiritual world. The work is eminently liberal, not so much from any peculiarity of the author's religious opinions, as from his fundamental position that the natural world is to be studied first, and its laws worked out as scientific verities, and that this scheme of order is to be rediscovered in the spiritual world as a part of the universal system. The position taken is not that of Horace Bushnell, who describes the spiritual world as "another system of nature incommunicably separate from ours"; and further says, "God has, in fact, erected another and higher system, that of spiritual being and government, for which Nature exists, a system not under the law of cause and effect, but ruled and marshaled under other kinds of laws." After referring to the argument as presented with acknowledged ability by Mr. Murphy in "The Scientific Basis of Faith," and to the reasoning of Butler's "Analogy," Mr. Drummond remarks: "After all, then, the spiritual world as it appears at this moment is outside of natural law. Theology continues to be considered, as it has always been, a thing apart. It remains still a stupendous and splendid construction, but on lines altogether its own." It is therefore the ambition of the author to show that the natural and spiritual worlds are constructed upon the same system, so that to the degree in which we understand the method of Nature shall we be prepared to understand the method of the spiritual world. By the implications of the argument, our first concern is with science, which elucidates natural truth; and as this is a gradual process, one science after another having slowly appeared in a necessary order of succession and preparation, the higher following the lower, so theology, the master-science, and to which all others are finally tributary, is to be developed by extending and establishing the natural laws in the spiritual sphere. It is a great thesis that Mr. Drummond has undertaken to illustrate and sustain, but he brings to the task a very able command of the results of modern science, an earnest and catholic spirit, and a reverent regard for the interests of truth, whatever forms they take. As a book of reconciliations, the volume is one of the best of its class.

FORESTRY IN NORWAY: with Notices of the Physical Geography of the Country. By JOHN CROUMBIE BROWN, LL. D. Edinburgh: Oliver & Boyd; Montreal: Dawson Brothers. Pp. 227.

THE series of Dr. Brown's books on forestry has already become quite a library (we find twelve volumes catalogued in the list prefixed to the present number), and bids fair to present all that is most important in the literature of the subject and in the experience bearing upon it. The present volume relates to a country in which the conditions are most favorable to forest-culture, and to the restoration of the woods as they are cut down. Yet the reports show that abundance has led to waste, and that, notwithstanding the great recuperative power of the Norwegian forests, they are becoming impoverished under the excessive drain that is made upon them. The greater part of the book is occupied with descriptions of the general and special features, geographical, topographical, and climatological, of Norway, and their influence upon the distribution and growth of the forests. The last chapter, on "Remedial Measures," gives account of the experimental plantations at Aas, the purchase by the Government of estates on forest-lands, and the allotment, in their several districts, of the forest officers of the government staff.

THE NEW PHYSICS. A Manual of Experimental Study for High Schools and Preparatory Schools for College. By JOHN TROWBRIDGE, Professor of Physics, Harvard University. New York: D. Appleton & Co. Pp. 367. Price, $1.50.

WE have especial pleasure in calling the attention of science-teachers in our higher grades of schools to this timely and valuable text-book. Its title, "The New Physics," is appropriate in a double sense, and is, in fact, the true key to the understanding of its character and claims.

But at the outset let us say that Professor Trowbridge's book is *not* new in the sense of treating of all the latest scientific novelties. It is not a digest of information on physical subjects for instructive reading and convenient reference, and makes no account of "the latest things" which it is often thought desirable to get into school-books, to "bring them up to the present time."

But the work is new, in the first place, as representing a great step of advancement in the fundamental ideas and general view of the subject, which is now properly designated "the new physics." No one discovery in the whole sphere of scientific thought has ever proved to be so profound and far-reaching in its influence as what Dr. Faraday calls "the highest law in physical science"—the law of the conservation of energy. The older views of the nature and laws of forces—the radical problem in physics—have been left behind us, antiquated by the emergence of the great principle of correlation and conservation which gives us a new and grander conception of the method of Nature. Professor Trowbridge has first made this principle basal in the study of elementary physics, and has chosen a title for his book which marks the present advance of the subject, and sharply contrasts his treatment of it with that of the older expositions.

In the second place, the method of teaching adopted is new in the sense that it is a progressive step in total contrast with the old and still prevailing method. This book is a guide to the study of phenomena. The pupil is taken through a systematic course of experiment in the laboratory, doing his own observing, his own manipulating, and his own thinking, and thus making his acquisitions real. The literary method of studying science is entirely discarded, with its vague results and all the possibilities of coaching and cram. The pupil goes to work at the threshold, and with the assistance and direction of competent teachers, which it is assumed he will have, he carves his way, and becomes thoroughly grounded in the facts and principles of the subject. "The New Physics" thus conforms to the spirit and embodies the method of "the new education."

Physics can not be truly taught without a laboratory any more than chemistry; but the apparatus necessary is not very expensive. On this point Professor Trowbridge says:

> An elementary laboratory of physics for a school, with experiments properly selected—for it is not necessary to cover the whole ground of experimental physics in order to gain a large amount of intellectual discipline—need not cost more than a chemical laboratory such as is now provided in many high schools. I have endeavored to describe only simple and inexpensive apparatus. The teacher can readily invent simple contrivances which, in many cases, will be better than those I have recommended. My endeavor has been to point out the way to a more rational method of studying physics. In the Appendix will be found additional directions for constructing simple apparatus. It is not supposed that the student will perform all the experiments in this treatise during the time that can be devoted to physics in the secondary schools. The choice of experiments by the teacher must necessarily depend upon the apparatus on hand, which can be modified for the purpose of this treatise, and upon the amount of appropriation which can be devoted to cheap apparatus.

It is frequently said that experimenting is more play than work, and that boys like it because it is easy. But this remark is not true of Professor Trowbridge's method of studying physics, in which, with regular manipulation, close thinking is enforced. This object is to secure that kind and measure of mental discipline which the study of physical science is capable of conferring; and that implies concentrated mental exercise upon actual laboratory processes, so as to arrive at accurate results. Of course, mathematics, the language of exactness, is indispensable, and is constantly used—arithmetic, algebra, geometry. But the amount of the latter needed to use the work is very moderate. Familiarity with simple equations and an elementary knowledge of square root are required, and, as explained by the author, as much trigonometry as can be got

almost at a single sitting. But these powerful instruments of precision in mental work are absolutely necessary if physics is to be taught for the purpose of mental training.

Professor Trowbridge aims to raise the standard in the elementary study of physical science, and to make its acquisitions of permanent value. He introduces nothing that can ever have to be unlearned. He has selected for experimental and mathematical demonstration the fundamental truths in the several branches of the science of physics, which must endure, however great the future advances may be. If the student masters the treatise, he has a solid foundation upon which all future advances must be based. He has omitted all that can not be considered as fundamental; and any laboratory manual which may be published in the future must include the principal experiments of this text-book.

Its appearance at this time is especially opportune, as it meets something like an emergency in the higher education. It is designed for the use of high schools, and also "preparatory schools for college," and there is just now a vigorous effort to raise the standard of science-study in the period of preparation for college. Here Greek and Latin have had almost exclusive attention, but there is a growing demand for a better pre-collegiate grounding in science. "The New Physics," if properly used, will insure this result. It will give a more valuable discipline than the dead languages; and, while there will be as much hard work as in the grinding of Greek, it will not be repulsive work. By enlisting the active as well as the reflective powers there will be a greater variety of interest in the exercises, so that the course of the student, though arduous, will be pleasurable. It is a fallacy to make disgust at painful study an evidence of its disciplinary value; and one of the great advantages which we may expect from the broader and more liberal pursuit of science-studies in the future will be to make education more attractive than it has been in the past.

HAND-BOOK OF THE DOMINION OF CANADA. By S. E. DAWSON. Montreal: Dawson Brothers. Pp. 335, with Pocket Map.

THE "Hand-Book" was prepared for the meeting of the British Association at Montreal, and therefore devotes more attention than is usual in guide-books to the scientific aspects of the country and its economical prospects. Opening with a general account of the Dominion, its physical features, statistics, enterprises of all kinds, and the condition of science, literature, and art within it, it devotes the sections that follow to more full and detailed accounts of Nova Scotia, Prince Edward Island, New Brunswick, Quebec, the lower St. Lawrence, the Labrador coast, Ontario, Manitoba, and British Columbia. A geological map of Montreal and its environs is given, in connection with a chapter on that subject.

EXCESSIVE SAVING A CAUSE OF COMMERCIAL DISTRESS. By URIEL H. CROCKER. Boston: W. B. Clarke & Carruth. Pp. 40. Price, 50 cents.

THE author of this monograph, which he characterizes as "a series of assaults upon accepted principles of political economy," is a prophet whose efforts have not been appreciated by the press. He is so unfortunate as to hold views contrary to the fashionable ones, and which, consequently, whether they be well founded or not, can not be admitted to the best places in the paper. The substance of these views is, that if the public refuse to buy goods that are in the market or are making for it, dealers and manufacturers who are dependent on the sale of them must suffer distress which will eventually overtake the whole community. A few of the essays he has written in support of this theory have been published; others have been declined or sent to the waste-basket. All are given in this volume.

ELECTRICAL APPLIANCES OF THE PRESENT DAY. By Major D. P. HEAP, U. S. A. New York: D. Van Nostrand. Pp. 287, with Plates.

MAJOR HEAP was sent out by the Secretary of War to visit the Electrical Exhibition in Paris in 1881, and collect such information respecting it as would be of interest and value. The exhibition was complete in nearly every detail except in the application of electricity to torpedoes, concerning which the inventors of every nation preferred to keep their own secrets from those of other nations. It was par-

ticularly remarkable for the number and variety of machines for generating electricity and for the appliances used in electric lighting, and these two subjects are treated in considerable detail. In some cases a slight history of antecedent inventions is prefixed to the description of objects exhibited, to show more clearly the progress and improvement made.

THE FALLACIES IN "PROGRESS AND POVERTY," ETC. By WILLIAM HANSON. New York: Fowler & Wells Company. Pp. 191. Price, $1.

BESIDES taking issue with Mr. George on some of the points in "Progress and Poverty" and "Social Problems," the author criticises Henry Dunning Macleod's "Economics" and adds chapters of his own on the "Ethics of Protection and Free Trade" and the "Industrial Problem considered *a priori*." Mr. Hanson is as radical as Mr. George, but differs from him in particular features of his views, especially as they bear on "the Law of Rent" and "Interest"; that is, Mr. George is too conservative for him. He appears to suggest a solution of all difficulties in the acceptance of Christian principles as he interprets them.

CHOLERA, AND ITS PREVENTIVE AND CURATIVE TREATMENT. By D. N. RÂY. New York: A. L. Chatterton Publishing Company. Pp. 128.

THE author of this treatise is a native, high-caste Indian, of English and American education, and is connected with the Dispensary of the Homœopathic Medical College in this city. He began to collect the material for his work in his native land, where he had the disease under constant observation. In his essay, in which he aims to group all the facts known respecting cholera, he considers the history of the disease, its etiology, modes of propagation, predisposing circumstances, the exciting causes, symptoms, complications, and sequelæ, and other accompanying features, the method of treatment, and the diet of the patient. Eight theories that have been brought forward to account for the origin of cholera are reviewed in the chapter on diagnosis. The treatment recommended is according to homœopathic principles.

ON A NEW METHOD OF RECORDING THE MOTIONS OF THE SOFT PALATE. By HARRISON ALLEN, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 34.

A NEW apparatus and its application are described in this volume, by which great delicacy is secured in transcribing the different motions, some of them extremely minute, of which the soft palate is susceptible. By it are recorded the changes that take place in the acts of swallowing, exhaling, coughing, hawking, sniffling, etc., and in articulation, even to the differences between the long and short sounds of the vowels. Dr. Allen suggests that his apparatus may have even a wider range of application than is delineated here, and that it may be made available for the comparative study of language, for the instruction of the deaf, and for the formation of a system of short-hand writing.

THE FORMATION OF POISONS BY MICRO-ORGANISMS. A Biological Study of the Germ Theory of Disease. By G. V. BLACK, M. D., D. D. S. Philadelphia: P. Blakiston, Son & Co. Pp. 178. Price, $1.50.

THIS volume contains a series of lectures which were delivered before the students of the Chicago College of Dental Surgery, and is divided into two parts. The first part embodies a review of the history and growth of the germ theory of disease, and is subsidiary to the second part, which is given, the author says, because he had "something to say that I thought ought to be said at the present time." The purpose of this "something to say" is to suggest a theory of the manner in which the germs act in producing disease. It is that, through the power which the bacteria possess in the remoleculization of matter, they cause the formation and diffusion through the system of organic alkalies having poisonous qualities comparable with those of strychnine.

THE ORCHIDS OF NEW ENGLAND: A Popular Monograph. By HENRY BALDWIN. New York: John Wiley & Sons. Pp. 158, with Plates.

THE variety and strange beauty of the tropical orchids, so much sought for for greenhouses, give to the family a rare popular interest; and the effort to make our people acquainted with the other members of

the family growing around them, many of which are so unobtrusive in color that they might escape notice unless attention were specially called to them, is to be in every way commended. According to Mr. Baldwin, the section of the United States lying east of the Mississippi and north of North Carolina and Tennessee produces fifty-nine species and varieties of orchids, of which forty-seven are found growing in New England. The matter of the present volume is adapted to satisfy both the general reader and the inquirer for exact facts and scientific details. First, we have Mr. Baldwin's general account, free from technical terms, of the family characteristics; then, the technical synopsis of the family in New England, from Gray's "Manual." This is followed by a popular essay of living interest on the different species, from which the element of gossip is not absent, and which, adorned with many graceful woodcut illustrations, forms the bulk of the volume. At the end are given a comparative list showing the range of each species, a bibliography, and a list of students of orchids in each New England State.

TAXATION IN THE UNITED STATES, 1789–1816. By HENRY CARTER ADAMS. Pp. 79. Price, 50 cents. INSTITUTIONAL BEGINNINGS IN A WESTERN STATE. By JESSE MACY. Pp. 38. Price, 25 cents. INDIAN MONEY AS A FACTOR IN NEW ENGLAND CIVILIZATION. By WILLIAM B. WEEDEN, A. M. Baltimore: N. Murray. Pp. 51. Price, 50 cents.

THE monographs named above are three numbers of the "Johns Hopkins University Studies of Historical and Political Science." The subject of the first work on the list is of more than usual current interest on account of its relation to the policy of so-called "protection" which still holds its grip on our national financial polity. The first measures of taxation to which the term "protective" may be applied appear from it to have been adopted when our government had hardly yet got under way, as a foil to the efforts of Great Britain to restrict our trade and prevent the growth of American commerce, and were wholly political in their aim. The beginning of systematic efforts to build up American manufactures through the operation of the tariff was of several years later date.

The second work traces the development of social and political institutions in Iowa during the period when the communities scattered over its soil were unorganized and not attached to any kind of government. The people met, voluntarily, within their own precincts and adopted such regulations as their circumstances demanded for the protection of their lives and property, and particularly for security in the possession and confirmation of their "claims." These proceedings were outside of all law, and in fact contrary to the laws of the United States relating to the public lands, but they created a custom "whose broad and beaten path leading directly across the statute obliterated every apparent vestige of its existence"; and from the foundations laid by them has been built up the present enlightened Commonwealth.

Mr. Weeden's essay gives new and enlarged ideas of the importance of wampum as a medium of trade in the early days of the colonies, and assigns it a place among real moneys having a solid value even when estimated by the criterion by which we are accustomed to judge the gold and silver currencies of commercial nations. From this aspect of the subject the author is led to consider the relations of the two civilizations which met on our continent nearly three centuries ago, and to show that the conflicts which arose and prevailed between the whites and the Indians were not the fruits of personal hostilities, and were not dependent on ambitions or caprice, but were the inevitable results of the diverse ways of looking upon life and its duties, and of the different religious systems, to which the two parties had been bred.

HAND-BOOK FOR HORSEWOMEN. By H. L. DE BUSSIGNY. New York: D. Appleton & Co. Pp. 75. Price, 50 cents.

A PLAIN, practical book for teaching women to obtain and maintain a seat on the horse and to manage the animal. While advising that the English method of letting the horse to a large extent control his own movements be not neglected, it devotes particular attention to the inculcation, in addition to that, of the Continental method of bringing the animal under complete control by securing the mastery of his hind-legs.

Recognizing that woman's seat on the horse is less secure and less convenient than man's, it assumes that she will encounter more difficulties in management, and therefore stands more in need of instruction, and of a different kind.

"CATHOLIC;" AN ESSENTIAL AND EXCLUSIVE ATTRIBUTE OF THE TRUE CHURCH. By Right Reverend Monsignor CAPEL, D. D. New York: Wilcox & O'Donnell Company, and D. & J. Sadlier. Pp. 150. Price, 30 cents.

THE author, an eminent English clergyman of the Roman Catholic Church, observed during his recent visit to this country that the Protestant Episcopal Church claimed to represent the Church Catholic here, as does also the Church of England in Great Britain. Believing that the title Catholic Church or Universal is exclusive and attaches of right to his own communion only, he has prepared the little work before us, "to try and establish who is the lawful possessor" of it. This he assumes to do in a spirit, not of controversy, but of "calm, honest investigation," drawing his arguments and illustrations from standard ecclesiastical authorities and history. To these he has added papers (in the version of the Oxford translations) bearing on the subject by St. Cyprian, St. Cyril of Jerusalem, and St. Pacien, Bishop of Barcelona, all of the third and fourth centuries, and from Lord Macaulay, of the present century.

MANUAL OF BIBLICAL GEOGRAPHY: A Text-Book of Bible History. By Rev. J. L. HURLBUT, D. D.; with an Introduction by Rev. J. H. VINCENT, D. D. Chicago: Rand, McNally & Co. (Continental Publishing Company.) Pp. 158. Price, $4.50.

THE gentlemen whose names are associated on this book are well known for their activity in the "Chautauqua" assembly and circles and in Sunday-school work. The book is designed for the use of students and teachers of the Bible and for Sunday-school instruction, to furnish a complete synopsis of Biblical and parallel contemporaneous history and of the geography of "Bible lands" at all periods, from the earliest down to apostolic times. In both plan and execution it is admirably adapted to its purpose. In clear maps, of quarto size, with pictures where they will help, and associated descriptive text in which the results of modern research are incorporated, it presents all the essential facts with reference to the countries, their physical constitution and topographical features, settlements, kingdoms, boundary and dynastic changes, migrations, and the journeys of leading Biblical characters, at each period of the history. As each epoch and each phase of the story is given a separate presentation, the occasional confusion, which is one of the prominent faults of most works of this kind, is wholly avoided.

INTRODUCTION TO THE STUDY OF MODERN FOREST ECONOMY. Pp. 228. FORESTS AND FORESTRY IN NORTHERN RUSSIA, AND LANDS BEYOND. Pp. 279. By JOHN CROUMBIE BROWN, LL. D. Edinburgh: Oliver & Boyd; Montreal: Dawson Brothers.

THESE are new volumes of the series of works on forestry which Dr. Brown is giving to the public, largely as a labor of love. It is an encouraging sign of the spirit of the times, in relation to this subject, that his efforts to fix attention on it are appreciated, and his books are well received both at home and in America. The first of the volumes named here assumes that forestry, or forest science, "relates to everything connected with forests, or pertaining thereto—EVERYTHING." In its three parts, which are further divided into chapters and sections covering details, are given what relate to the extensive destruction of forests, and its evil consequences; the "Elements of Modern Forest Economy"; and "Forest Administration." In the second volume are given descriptions of the forest-lands of the several forest districts of Russia and "Nova Zembla and Lands beyond"; forest exploitation as practiced upon them; and accounts of the physical geography, flora, paleontological botany, and fauna of the several regions.

SOUTH CAROLINA. Resources and Population, Institutions and Industries. Published by the State Board of Agriculture. Charleston: Walker, Evans & Cogswell. Pp. 726. (Compiled by Harry Hammond.)

THIS volume gives a full and minute account of the State to which it relates in all

its aspects, and by counties and towns. The general physical characteristics of South Carolina as a whole are described in the introductory chapter, while the six chapters that follow it are devoted to the several "regions" into which the State is divided, according to the character of their topographical features and products, viz.: the "Coast Region," the "Lower Pine Belt, or Savannah Region," the "Upper Pine Belt," the "Red Hill Region," the "Sand Hill Region," the "Piedmont Region," and the "Alpine Region." The ninth chapter is devoted to the water-powers, and in the three chapters that follow it are given lists of the vertebrate animals, of the invertebrate fauna, and of the plants of the State. In the second part of the volume are reviewed the statistics, relations, and movements of the population, the vital statistics, and the institutions of the State; a sketch of "Education" is inserted; and full information is given respecting the churches, occupations, the insane, etc., the history and present condition of transportation, "Debt and Taxation," and the "Farms of South Carolina."

PUBLICATIONS RECEIVED.

Opium Addiction among Medical Men. Pp. 9. The Genesis of Opium Addiction. Pp. 8. By Dr. J. B. Mattison, Brooklyn, N. Y.

A Periodical Painful Affection. Pp. 19. Irritation of the Prostate. Pp. 7. By Harvey Reed, M. D., Mansfield, Ohio.

The Volcanic Problem from the Point of View of Hawaiian Volcanoes. By W. L. Green, Honolulu. Pp. 7.

Man in the Tertiaries. By Edward S. Morse, Salem, Mass. Pp. 12.

"Journal of the Elisha Mitchell Scientific Society," 1883–1884. J. W. Gore, Secretary, Chapel Hill, N. C. Pp. 97.

Yellow Fever at Norfolk and Portsmouth, Virginia, in 1855. Pp. 19. Reparative Surgery. Pp. 10. By F. B. Stevenson, M. D., U. S. Navy.

Tobacco: Its Uses and Effect on the Human System. By Lemuel Clute, Ionia, Mich. Pp. 6.

Massachusetts Agricultural Experiment Station, Amherst. Bulletin No. 11. Pp. 12.

New York Agricultural Experiment Station. Report for 1883. Albany: Wood, Parsons & Co. Pp. 279.

The History and Philosophy of Atheism. By Professor A. H. Darrow, Hartford, Kansas. Pp. 71. 25 cents.

Bureau of Iowa Agricultural College, Department of Entomology. By Herbert Osborn, Ames, Iowa. Pp. 56, with Plates.

Descriptive Catalogue of Sections (Microscopical) of Rocks. By Dr. M. E. Wadsworth. Boston: The Prang Educational Company. Pp. 20.

Chicago Manual Training-School. Inaugural Address of the Director, Henry H. Belfield. Pp. 15.

Proper Medical Education. By Henry Leffman, M. D. Pp. 8.

Protection and Free-Trade To-Day. By Robert P. Porter. Boston: J. R. Osgood & Co. Pp. 48. 10 cents.

Diccionario Tecnológico. Part VIII. By Nestor Ponce de Leon. New York: N. Ponce de Leon. Pp. 48. 50 cents.

The True Issue (Tariff Reform). By E. J. Donnell. New York: G. P. Putnam's Sons. Pp. 79.

A Dictionary of Music and Musicians. Part XIX. By George Grove, D. C. L. New York: Macmillan & Co. Pp. 128. $1.

Alexander the Priest. By William A. Swank. Pp. 40.

Suggestions respecting Educational Exhibit (Bureau of Education). Washington: Government Printing-Office. Pp. 281.

Russell's Improved Process for the Lixiviation of Silver-Ores. By C. A. Statefeldt, New York. Philadelphia: Sherman & Co. Pp. 72.

On the Amount of the Atmospheric Absorption. By S. P. Langley. Pp. 18.

Fifth Annual Report of Sapporo Agricultural College. Japan, 1881. Pp. 84.

The Psychical Relation of Man to Animals. By Joseph Le Conte. Pp. 26.

Town and County Government in the English Colonies of North America. By Edward Channing. Baltimore: N. Murray. Pp. 57. 50 cents.

Modern Low-Cost Houses: Shoppell's Building Plans. New York: Co-operative Building-Plan Association. Forty Designs. 50 cents.

The Steam-Engine Indicator and its Use. By William Barnet Le Van. New York: D. Van Nostrand. Pp. 169. 50 cents.

Ogilvie's Handy Book of Useful Information. Compiled by J. S. Ogilvie. New York: J. S. Ogilvie & Co. Pp. 128. 25 cents.

Correspondences of the Bible. The Animals. By John Worcester. Boston: Massachusetts New Church Union. Pp. 294. $1.

Essays by Wheelbarrow. Chicago: "Radical Review." Pp. 132.

Practical Work in the School-Room. Object-Lessons on the Human Body. New York: A. Lovell & Co. Pp. 157.

Education by Doing. By Anna Johnson. New York: E. L. Kellogg & Co. Pp. 109.

"The Jukes." Studies of Criminals. By R. L. Dugdale. New York: G. P. Putnam's Sons. Pp. 120, with Charts. $1.25.

Tableaux de la Révolution Française (Introductory French Reader). By T. F. Crane and S. J. Brun. New York: G. P. Putnam's Sons. Pp. 311. $1.50.

A Grammar of the German Language. By H. C. G. Brandt. New York: G. P. Putnam's Sons. Pp. 278. $1.50.

A Reader of German Literature. By W. H. Rosenstengel. New York: G. P. Putnam's Sons. Pp. 402. $1.50.

An Outline of the Future Religion of the World. By T. Lloyd Stanley. New York: G. P. Putnam's Sons. Pp. 588. $3.

Life and Labor in the Far, Far West. By W. Henry Barneby. London and New York: Cassell & Co. Pp. 432. $2.

Mineral Resources of the United States. By Albert Williams, Jr. Washington: Government Printing-Office. Pp. 813.

The National Dispensatory. By Alfred Stillé, M. D., and John M. Maisch, Phar. D. Philadelphia: Henry C. Lea's Son & Co. Pp. 1,755.

American Newspaper Annual. 1884. Philadelphia: N. W. Ayer & Son. Pp. 994. $3.

Transactions of the Linnæan Society of New York. Vol. II. New York: Published by the Society. Newbold T. Lawrence, Corresponding Secretary. Pp. 283, with Plate.

POPULAR MISCELLANY.

British Association Addresses.—Professor Roscoe's address before the Chemical Section was on "The Progress of Chemistry since 1848." The author made the year 1848 a dividing line between the epoch of Berzelius, which closed then, and that of Dumas and Wurz, which closed in 1884. The differences between the two epochs are shown in the distinct views which were entertained as to the nature of a chemical compound. According to the older notions, the properties of compounds were determined largely by the qualitative nature of their constituent atoms, and these were arranged so as to form a binary system. According to the newer view, it is mainly the number and arrangement of the atoms in a molecule that regulate the characteristics of a compound, which is to be regarded, not as built up of two constituent groups of atoms, but as forming a single group. The theory of substitutions, the relation of atomic weights and volume-combination, the prominent part assigned to organic radicals, the doctrine of valency or atomicity, and Mendelejeff and Lothar Meyer's periodic law, under which we may predict the nature and place of as yet undiscovered elements, and the study of isomeric phenomena, are also distinctive marks of the later chemistry. The artificial synthesis of a few coloring-matters and of kairine, a febrifuge as powerful as quinine, are among its most noteworthy achievements. Of the work that has been done in the determination of chemical constants, the labors of Mallet on aluminum, of J. P. Cooke on antimony, and of Thorpe on titanium, are especially mentioned. The speaker gave accounts of the progress that has been made in spectrum analysis, and the close distinctions of the molecular properties and constitution of bodies which it has made possible. Other indications of progress are given in Sir William Thomson's speculations on the probable size of the atoms; Helmholtz's discussion of the relation of electricity and chemical energy; and the theory of the vortex-ring constitution of matter, as suggested by Sir William Thomson and worked out by Mr. J. J. Thomson. Much experimental attention is now given to thermo-chemistry. The discovery of the liquefaction of the gases by Pictet and Cailletet, including Andrews's discovery of the critical point, indicates a connection, long unseen, between the liquid and the gaseous states. Deville's investigations of the laws of dissociation have opened out entirely fresh fields for research, and given new, important, and interesting views concerning the stability of chemical compounds. Professor Roscoe considered the best methed of educating chemists to consist in giving them as sound and extensive a foundation in the theory and practice of the science as their abilities will allow, rather than in forcing them prematurely into original preparations and investigations.

Mr. W. T. Blanford, President of the Geological Section, presented some remarks upon contradictions which had been observed in certain districts, in the determination of the age of geological formations as indicated by their fossils. The most of them occur where a land or fresh-water fauna or flora assigned to a particular formation rests upon a marine bed of apparently later origin: as in Greece, where the supposed Miocene fauna of the Pikermi beds overlie strata with Pliocene mollusca; and in certain described places in India, Australia, and South Africa. Only one case of contradiction between two marine formations is known, and that is in dispute. In making choice between the two witnesses, geologists take the marine formations; for marine faunas and floras are more widely diffused than those of the land, and more nearly uniform throughout the world. Thus, of fishes, eighty families are typically marine, and twenty-nine are confined to fresh water; of the first, fifty are universally or almost universally distributed; while of the second, only one is found in five of Wallace's regions, and not one is met with in all the six regions. Among plants, so uniform is the marine vegetation of the world, that no separate regions can be established in the ocean, while Drude makes fourteen on the land. It appears to the author that at the present day the difference between the land faunas of different parts of the world is so vastly greater than that between the marine faunas that, if both were found fossilized, while there would be but little difficulty in

recognizing different marine deposits as of like age from their organic remains, terrestrial and fresh-water beds would in all probability be referred to widely differing epochs, and that some would be more probably classed with a past period than with others of the present time. The idea that marine and terrestrial faunas and floras were similar throughout the world's surface in past times is so ingrained in paleontological science that it will require many years yet for the fallacy of the assumption to be generally admitted. No circumstance has contributed more widely to the belief than the supposed universal diffusion of the carboniferous flora. The evidence that the plants which prevailed in the coal-measures of Europe were replaced by totally different forms in Australia, despite the closest similarity between the marine inhabitants of the two areas, should go far to dispose of this belief. Hence, determinations of the age of terrestrial beds based upon their fossil faunas and floras should not be accepted as fixed unless they are accompanied by evidence from marine beds.

Discussing the "Physiology of Deep-Sea Life" in the Biological Section, Professor Moseley, of the Challenger Expedition, having recognized the value of the work that had been done in deep-sea investigation in the United States, spoke of the importance to the physiologist of a knowledge of the conditions under which gases occur in a state of absorption in the ocean-waters. Professor Dittmar's researches show that the presence of free carbonic acid in ocean-waters is an exception. Hence, the solution which some shells undergo at certain depths is probably due, not to the presence of free acid, but to the solvent action of the sea-water itself. Oxygen is present in all sea-water, being derived from the surface, but the amount diminishes, on account of the oxidizing that is always going on, with increase of depth. M. Regnaud's experiments on the effects on organisms of high pressures, corresponding with those of certain sea depths, show that a fish without a swimming-bladder, or one with the bladder emptied of air, may be subjected to a pressure of 100 atmospheres, or 650 fathoms, without injurious effect; at 200 atmospheres, or 1,300 fathoms, it becomes torpid, but soon revives when the pressure is removed; while at 300 atmospheres, or about 2,000 fathoms, the fish dies. The results of these experiments would probably have been greatly modified, if plenty of time could have been given for the fish to accommodate itself to the change of pressures and the conditions in which it moves slowly from one depth to another be imitated. M. Paul Bert's experiments upon the effect on aquatic organisms of water subjected to the pressure of compressed air—a very different condition—show fatal results at fifteen and even at seven atmospheres. A large proportion of the food-supply of the deep-sea animals appears to be derived from life on the ocean-surface, or that which is brought to the surface by rivers from the land sinking down to it. Deep-sea life appears to diminish in abundance as the coasts are receded from. More may be known on this subject when we have learned more about pelagic vegetable life, with which our acquaintance is now imperfect. If it shall be ascertained that the deep sea derived its main supply from the coasts and land-surfaces in the early periods, there can have existed scarcely any deep-sea fauna until the littoral and terrestrial faunas and floras had become well established. It still appears impossible to determine any successive zones of depth in the deep-sea regions, characterized by the presence of special groups of animals. Some groups seem to be characteristic of water of considerable depth, but representatives of them struggle up into much shallower regions. This fact places a difficulty in the way of determining the depths at which the geological deposits were formed. Something may be learned of the depths of modern deposits by the examination of their microscopical composition and the condition of the shells and spicules. Great uncertainty prevails as to whether, or to what extent, the intermediate waters, which are held to include about eight ninths of the bulk of the entire ocean, are inhabited by animals. A feature of the deep-sea fauna is the general absence from it—except as to mollusks and brachiopods—of palæozoic forms. This fauna has, doubtless, been derived almost entirely from the littoral fauna, which also must have preceded,

and possibly given rise to, the entire terrestrial fauna. And because the ancestors of nearly all animals have passed through a littoral phase of existence, preceded mostly by a pelagic phase, the investigations now carried on, on the coasts, in marine laboratories, throw floods of light on all the fundamental problems of geology.

General Lefroy, in his address before the Geographical Section on "Recent Geographical Discovery" referred to the more exact identification of the pole of vertical magnetic attraction or magnetic pole, which was visited by Ross and by officers of the Franklin Expedition, and nearly reached by McClintock and Schwatka; and of the focus of greatest magnetic attraction, which is near Cat Lake, and has never been visited; and the exploration of the newly discovered great lake Misstassini, as worthy objects of Canadian research. Among the later achievements of geographical exploration are the journey of Mr. Thomson through the region between Mount Kilimanjaro, Lake Nyanza, and Mount Kenia, touching Lake M'Baringo on which no European had ever before stood, among tribes who had never seen a white man; Stanley's and De Brazza's continued explorations of the Congo region; and the work of Dr. Pogge, Lieutenant Wissman, and the Portuguese explorers in the southern Congo, Upper Quango, and Loando regions. According to Dr. Pogge, much of the interior of Africa belongs, by reason of its elevation above the sea, to a far more temperate zone, and is better suited to European constitutions than its geographical position promises. In illustration of the rapid extension of white occupation in Central Africa, a table is given of about one hundred and twenty actual centers of communication or trade, or of missionary instruction, now established there. Lake Nyassa is becoming a busy inland sea. There are two steamers upon it, and one on the river Shiré; upon Tanganyika three. Donkeys have been already introduced, with good promise, by the universities' missionaries and the African Lakes Company, although they have not been a success on the Congo. The African Lakes Company, of Glasgow, has ten small depots between Quillimane and Malawanda on Lake Nyassa, and from this place a practicable road of two hundred and twenty miles has been carried to Pambete, on Lake Tanganyika.—In Asia, Mr. W. W. Graham has reached in the Himalayas an elevation of 23,500 feet, or about 2,900 feet above the summit of Chimborazo; some progress has been made, by the aid of disguised Indians, in the surveys of territories from which Europeans are excluded; the primary triangulation of India, begun in 1800, is practically completed; and the upper Oxus has been traced from its sources in the Punjaub. Australia has been crossed again from east to west, and also through four hundred miles of new country north of Cowarie Station on the Warburton River, and the usefulness of camels in that service has been demonstrated.—The international circumpolar expeditions have added, perhaps, to local knowledge, but not much, so far as reported, to geography generally. The discoveries made by Greely's party are mentioned appreciatively. The results of the marine researches of the Talisman and the Dacia in the Atlantic Ocean are of great value. Reference was made to the extension of railroads in Mexico, South America, the Senegal, the Caucasus, and Central Asia, as marking steps in the advance of man's mission to subdue the earth and replenish it; and the importance was insisted upon of obtaining accurate map delineations in aid of the exact determination of boundary-lines and the avoidance of disputes about them.

"The Relation of Mechanical Science to the other Sciences" was the topic of Sir F. J. Bramwell's address before the Mechanical Section. He called attention to the fact that it was the engineer who had made a meeting of the Association in Canada possible. Every one must agree that the engineers are those who make the greatest practical use, not only of the science of mechanics, but of the researches and discoveries of the members of the other sections of the Association. Knowledge of the laws of heat is requisite in the construction of thermal motors; in the applications to metallurgy, as exemplified in the hot blast, in the regenerative furnace, in the dust-furnace of Crampton, in the employment of liquid fuel, and also in operations connected with the

rarer metals, the oxygen-furnace, and the atmospheric gas-furnace, and, in its incipient stage, the electrical furnace. The success of air-refrigerating machines and the economic distillation of sea-water are dependent on the same knowledge. Engineering and electrical science are brought into close relations in the construction of telegraph and cable lines, in the development and application of dynamo-machines and dynamo-energy, and in electric lighting, telephony, and microphony. In navigation, the engineer avails himself of optical science in the equipment of lighthouses; of pneumatics in Sir William Thomson's apparatus for taking quick soundings, and of magnetic science in his adjustment of improved compasses. Mathematical principles enter into the construction of ship-models. In the processes of the preparation from the ore of various metals, "it is essential that the engineer and the chemist should either be combined in one and the same person, or go hand in hand." The chemist and the microscopist have to be called in to ascertain the purity of every contemplated source of water-supply; and the chemist, when it is desired to convert a hard water into soft. Engineers must consult the geologist before they can intelligently make estimates of the works they are about to undertake. In biology, the engineer learns from the botanist the qualities of the various woods he occasionally uses in his work, and has the "germs" in view in arranging for the purity of water-supply and for ventilation. Lastly, great works of engineering facilitate geographical exploration, and are called into existence by the dictates of the economist. The speaker closed his address with a tribute to the memory of Sir William Siemens.

Cultivation of Cacao.—The cacao-tree flourishes in the hot regions of America, and has been cultivated since the conquest in Mexico, Guatemala, and Nicaragua. To secure success, the cacao-plantation must be made in new land, for the tree requires a rich, deep, and moist soil, and heat. The best situation is cleared forest-land, so inclined as to permit its being irrigated. The cultivation of the trees often ceases to be profitable when the temperature falls below 78°. The cacao seldom blossoms till it is thirty months old. The planters destroy the first flowers, in order to prevent fruiting before the fourth year. There are few plants in which the flower is so small and so disproportioned to the size of the fruit. A bud measured by M. Boussingault, at the time of its expansion was not more than four millimetres broad. The flesh-colored corolla was composed of ten petals surrounding five silver-white stamens. The flowers did not appear singly, but in bouquets on every part of the trunk, on the principal branches, and even on the salient wood-roots. The fruit comes to maturity in about four months after the fall of the flowers. It is about ten inches long and three or four inches in diameter, slighty curved, weighs three hundred or five hundred grammes, and is divided into three lobes. Its color varies from a greenish-white to a red-violet. The pericarp is furrowed longitudinally within; the flesh or pulp is rosy-white and acid, and generally envelops twenty fine, white, oily kernels which in drying assume a superficial brown tint. Two principal crops are harvested every year, but on large plantations the gathering is going on all the time, and it is not uncommon to see trees bearing both flowers and fruits at the same time. After breaking the shell, the nuts are taken out and exposed to the sun. In the evening they are piled up under a shed. An active fermentation soon sets in, which must not be allowed to go too far, and, accordingly, the nuts are on the next day spread out in the air. The cultivation of a cacao-plantation does not demand much labor. One man can take care of a thousand trees. The most serious difficulties are the dangers from storms, which are very destructive to the fruit; otherwise the principal duty of the attendant is to protect the crop from animals. The cacao is shelled by roasting at a moderate heat, in which process it acquires, like the coffee-bean, an odor arising from a minute proportion of a volatile principle which it contains. This is the peculiar aroma which we perceive in chocolate. The cacao-beans are rich in nutritious principles, containing a fat, nitrogenous substance analogous to albumen and caseine, theobromine and ternary compounds, all of which vary somewhat in their relative quantities. The theobromine is almost identical with the caffeine of coffee and the theine

of tea, and is essentially the same principle that gives value to those substances and to the *maté* of Paraguay and the coca of Peru. Thus, in the several drinks prepared from these substances, the Chinese, the Arabs, and the Indians of Mexico and South America enjoy the influence of the same cheering but not inebriating agent. Cacao and chocolate differ from the other beverages named in that they contain a notable proportion of nutritious elements which exist in the others only in minute quantities.

The Question of Short-Sightedness in French Schools.—A commission appointed by the French Government to investigate the question of short-sightedness in schools recently made a report through Dr. Gariel. It declares that the affection is caused by the efforts of the pupil to accommodate his vision to the requirements of the position in which he finds himself, and by his bending over. These effects are provoked by defective lighting, badly fitting seats and desks, bad methods of writing, premature instruction, and too fine print. The commission recommend, for books, yellowish-tinted paper; that each line with its white should occupy a minimum vertical space of 3·384 millimetres; and that there should not be more than seven letters to each current centimetre of text. Furthermore, every book should be rejected which is not readable to good eyes eighty centimetres or thirty-one inches off in the light of a standard candle one metre away, and every map that is not distinct under the same conditions at a distance of forty centimetres, or sixteen inches. In regard to habit in writing the committee exacts George Sand's condition of "straight writing, on straight paper, with a straight body." Instruction should not begin too early, at least not in writing on paper; and the child should not be put at it till it has learned to trace the letters on a board, upright, and without linking them together. In the matter of seats and desks, the committee appear to exact that the horizontal distance between the edge of the desk and the front of the seat one or two places back shall be rigorously negative; then the child will not be able to bring his chin down to his desk. The back should be inclined to fit the pupil's back and give a position of rest, and the desks should slant so that the paper lying on them should be perpendicular to the visual rays. The larger classes should have movable chairs. If there is not enough light, the pupils should be allowed to hold their books so that they can get the most of it. An Italian journal has published a model of a seat well adapted to fit the back of various sizes to suit deficient eyes, and so adjusted that the child can take a nap, if sleepy, without suffering. The hardest question the committee had to meet was that regarding the admission of light. It was agreed that a sufficient illumination of the darkest part of the room should be the standard, and that a bit of sky not less than thirty centimetres, or twelve inches, in vertical diameter ought to be visible from the least favored spot; but the expediency of bilateral illumination does not yet seem to be determined to thesatisfaction of all: some thought cross-lights might give trouble; others suggested that this could be avoided by making the light from one side much stronger than from the other, or by making the light come from above or from behind.

Natural Gas as a Source of Fuel.—An important change in the conditions of manufacturing in Pittsburg is promised by the introduction of natural gas as fuel in place of coal. The gas, which is principally carbureted hydrogen, or the fire-damp of the mines, is obtained abundantly in the neighborhood of the city, and even within its corporate limits, by boring wells. Much of it has been met in the past in boring for petroleum, and when found under such circumstances it was regarded as a nuisance. Some of the wells thus discovered have already been applied to economical uses, and found as valuable as if they had been petroleum-wells. Such wells are employed for burning brick at New Cumberland, and in the manufacture of pottery at East Liverpool, of cutlery at Beaver Falls, and of glass-ware at Rochester. The gas of six wells is brought through pipes twenty miles to the city and used to heat the boilers of an iron-manufactory; and it has been found that, where the distance of the supply is so short that the gas can be brought in without its pressure being wholly lost in piping, it can be made a valuable addition to the

resources for fuel. A very fine vein of gas has been found by sinking a well within the limits of the city, and several manufacturers have begun boring for it on their premises. Twenty-six wells are now furnishing gas to manufacturers in the Pittsburg district, and new ones are added from time to time. They are estimated to be furnishing a supply of fuel equivalent to from 5,000 to 7,000 tons of coal daily, or from 1,800,000 to 2,500,000 tons a year. The gas makes a nice and even fire in grates and stoves, but objection is made to its use in private houses on account of its freedom from odor, by which the detection of leaks is prevented, and the danger is incurred of the air of the house being fatally poisoned before any one becomes aware that anything is wrong. Its light is too weak to make it suitable for illuminating purposes. Its advantages over coal lie in the possibility of supplying it at much less expense, and in its entire freedom from soot and smoke—a matter of extreme importance in such a city as Pittsburg.

NOTES.

An "American Electrical Exhibition" will be opened in the Massachusetts Charitable Association Building, Huntington Avenue, Boston, November 24th, and will be continued till January 3, 1885. It is intended to make the exhibition complete and comprehensive in every particular, and to exceed in novelty any that has ever been held in New England. The rooms will be open for the reception of exhibits from November 5th to November 19th. Applications for space must be made by November 1st. Communications should be addressed to "American Electrical Exhibition, Post-Office Box 1130, Boston, Massachusetts."

Mr. D. H. Talbot describes, in the "American Naturalist," a specimen of the ground squirrel in a state of hibernation which he had an opportunity of observing. It was rolled up in a perfect ball, with its head resting forward of the root of the tail, and the tail curled carefully up on the body. It was resting in a perfectly closed ball of hay twelve or fourteen inches in diameter in the center of a hay-stack. It was evidently alive and healthy when found, though quite dormant, but either in consequence of having been inconsiderately exposed unwrapped to extreme cold by the finder, or of some change that took place while it was in Mr. Talbot's keeping, it grew limp, suffered hæmorrhage, and died.

A correspondent calls attention to a clerical error—a genuine case of what Richard Grant White would call heterophemy—that escaped notice in the proof-reading, by which we were made, in the September number, in recording the death of Henry Watts, to say that he had been a "demonstrator of anatomy" in University College, London. "Director in the laboratory" was what it should have been, and what was intended.

Mr. W. H. Preece stated in the British Association that he had been fairly successful in telephoning through the cable between Dublin and Holyhead, a distance of sixty miles. Accurately heard conversation, however, could not be carried on through cables beyond a distance of twenty-five miles; and it seemed at present impracticable to use underground wires in cities for distances of more than twelve miles. On overground wires he had no difficulty, with an arrangement of double lines, in speaking through two hundred and forty miles.

Professor Claypole read a paper, before the Geological Section of the British Association, on the crumpling of the earth's crust as shown by a sixty-five-mile section across Huntingdon, Juniata, and Perry Counties, Pennsylvania, in which he estimated by mathematical methods that the strata had been shortened, by the foldings they had undergone, from an original length of about one hundred miles. That the contraction had been so great was disputed by some of his hearers, but Professor Claypole held to his conclusions.

The commission, appointed by the French Minister of Public Instruction, to verify the results of M. Pasteur's experiments on the prevention of hydrophobia by inoculation, has pronounced them decisive. The problem whether inoculation of a human being, after he has been bitten, can be relied upon to secure him against contracting the disease, is still under investigation. Time and many subjects will be needed before a rigorously exact solution of it can be reached.

The temperatures of the boiling-points of the liquid forms of certain gases, as determined by Mr. Wroblewski, were given in our September number with the minus-signs undesignedly omitted. Most readers would understand, as of course, that temperatures below zero were intended. For the benefit of those to whom this may not have occurred, we repeat the temperatures: oxygen -299° Fahr.; atmospheric air—314°; nitrogen — $315{\cdot}5^\circ$; carbonic oxide — $314{\cdot}4^\circ$; and we may now add, hydrogen—351°.

Sir John Lawes and Dr. Gilbert maintained, in a paper before the British Association, that the view which has been held

that a soil is a laboratory and not a mine, is erroneous; for not only the facts adduced by them in previous papers, but the whole history of agriculture, so far as we know it, show that a fertile soil is one which has accumulated within it the residue of ages of previous vegetation, and that it becomes less fertile as this residue is exhausted.

DR. CORBOLD, an eminent authority on the subject, asserts that the danger of eating parasites in fish used as food is much exaggerated, and that there is extremely little of it. If the fish are only moderately boiled, the parasites will all be killed, and, if they are not, not one in a thousand of them will find itself at home enough in the human stomach to do any harm. Professor Huxley also declares that the thread-worm of the mackerel is harmless, and that the idea of its being a possible cause of cholera is sheer nonsense; and he thinks it outrageous that the suggestion has been made.

MASKS of mica are made at Breslau for the use of workmen who are exposed to high temperatures, to acid vapors, or to metallic sparks. They are found to protect the eyes better than glasses, while there is space enough between them and the eyes to permit spectacles to be used also. The plates of mica are fixed in metallic supports protected with amianthus, and the neck and shoulders of the workman are covered with a hood of that substance.

THE Eilsitt bridge, Lyons, France, is called "the singing-bridge," on account of the musical sounds it emits at different parts of its course, "when at particular moments one might believe it haunted by legions of invisible naiads pursuing the passengers with their plaintive melodies." The bridge is furnished with a stone parapet, which is pierced at intervals for light, with rectangular openings having their ends rounded off in semicircles. The effect of this passage, with the air-currents rushing through it, is that of a flute, of which the windows represent the holes. The tones vary considerably at times in intensity, with but little difference in their pitch.

THE prairie-wolf has been introduced into Epping Forest, England, and appears to be breeding freely there. The animals have been confounded by some persons with cubs of the fox, and described by others as "strange animals from foreign parts." One of them was recently offered to Mr. Bartlett, Superintendent of the London Zoölogical Gardens, who, doubting whether it might not be a hybrid of some kind, visited the forest to learn something more about its real character. The less frequented parts of the forest seem well suited to the habits of the animals, and they promise to thrive.

DR. RICHARDSON has sounded a note of warning against the too hasty and complete acceptance of the bacillus theory for the origin of every kind of infection, to the neglect "of all the preceding clinical history." He asks: "Upon the evidence of how many or how few men does the bacillus hypothesis rest? On what reasoning does it rest? Who has separated, in relation to it, coincidence from causation?" To ask these questions, or to heed them, is not necessarily to question the validity of the bacillus theory, but simply to pause and review, and ask for the proof of it.

THE question whether the water of a river like the Thames, when once polluted by sewage, can be made fit for drinking purposes, either by the oxidation incident to its own flow or by artificial filtration, was again up for discussion recently before the London Society of Arts. Dr. Frankland took the negative side upon it, and insisted that the Thames's supplies to London should be abandoned; while many eminent engineers and a few chemists positively contradicted both his data and his conclusions. Mr. W. Mattieu Williams suggests that the force of the latter gentlemen's opinions is somewhat detracted from by the fact that most of them are concerned in the construction of filter-beds and other engineering appliances for river-water purification, or in schemes for chemical precipitations.

THE ice-plant of our ladies' window-baskets (*Mesembryanthemum crystallinum*) affords a striking illustration of the elective power which plants have of taking up by their roots from a complex soil the materials proper for them. M. Mangon has cultivated it for several years on the same ground with cabbage, celery, and other plants, and has found that, while the latter plants had their normal composition, the ice-plant, dried and burned, furnished an ash with an amount of chlorine and alkali that astonished him. From one hectare, or two acres and a half of ice-plants, he obtained 1,820 kilogrammes of ashes, containing 335 kilogrammes of chlorine, as much soda, and 588 kilogrammes of potash, the latter of which substances was capable of furnishing 863 kilogrammes of carbonate of soda, or nearly as much as is got from the incineration of one hectare's yield of the salt-works at Alicante. M. Mangon suggests that this plant might be cultivated for a potash-plant, and that it might be made serviceable in removing the excess of alkaline salts from salt grounds.

A CORRESPONDENT of "Nature" writes from Java that, having recently killed one of the venomous snakes of that island, he noticed the tail of a second snake sticking from its mouth, and found that it had swallowed another individual of the same species, and nearly the same size with itself.

EDWARD BURNETT TYLOR.